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A MANUAL OF SURGERY

A Manual of Surgery

BY

CHARLES STONHAM, F.R.C.S.Eng.

SENIOR SURGEON TO THE WESTMINSTER HOSPITAL; LECTURER ON SURGERY AND ON CLINICAL SURGERY, AND TEACHER OF OPERATIVE SURGERY, WESTMINSTER HOSPITAL; SURGEON TO THE POPLAR HOSPITAL FOR ACCIDENTS; EXAMINER IN SURGERY, SOCIETY OF APOTHECARIES, LONDON; LATE MEMBER OF THE BOARD OF EXAMINERS IN ANATOMY UNDER THE CONJOINT SCHEME FOR ENGLAND, ETC. ETC.

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CHAPTER I

Antiseptic Surgery

All modern surgeons employ the antiseptic method in operations and wound treatment, and although there is no one plan of procedure in universal use, the variations in the technique are all based on the same fundamental principles.

The employment of antiseptics is founded upon a knowledge of the conditions favouring and exciting putrefaction of discharges and infection of wounds, and the study of the means by which such may be prevented (*Bacteriology*, chap. vi. p. 87, vol. i.)

The practice thus aims at attaining the following conditions:—

(1) *The exclusion from a wound of all micro-organisms, many of which have been shown to be the exciting causes of putrefaction and infective processes.*

Such exclusion is effected by thorough cleansing of the part and by complete disinfection of the surgeon's hands and of all ligatures, sutures, sponges, and instruments which are used. At the present day it is generally conceded that air-borne organisms are chiefly non-pathogenic, and do not (under ordinary sanitary environment) possess that importance which was formerly accorded them; direct inoculation of a wound by accidental circumstances, unclean sponges, etc., is the method by which disease processes are excited, and the avoidance of such contamination is the sure way to achieve the most brilliant results of the antiseptic method.

(2) *The removal of discharges which form a fitting pabulum and culture medium for any organisms which may be present.*

In operation cases the amount of serous exudate which drains away may be very slight, especially if the operation has been care-

fully performed and the wound has not been unduly irritated by the use of strong antiseptics. Under such circumstances drainage is unnecessary, but in large and deep wounds a drainage tube should be used.

In accidental wounds, which are so frequently infected, the removal of all dirt is essential, and drainage must be employed to remove the discharges and possibly the poisons due to putrefactive changes which may occur in such wounds in spite of all precautions.

(3) *The application of a suitable antiseptic dressing which will readily absorb any discharge which may escape.*

The antiseptics with which such dressings are impregnated chemically split up the albumen contained in the discharge and thus render it unfit for bacterial growth. The dressing, moreover, allows of evaporation, filters the air passing through it, and, if properly adjusted, protects the wound against future contamination from without.

(4) *The general health of the patient and the vital condition of the tissues to be operated on should be as good as possible.*

If these desiderata be attained, the depression of vitality necessarily induced by any operation is reduced to a minimum, and thus the natural tendency to heal is encouraged, and the tissues are to a great extent capable of dealing with any organisms which may have gained entrance.

The practice of antiseptics necessitates attention to the minutest details; neglect of any precaution, however slight it may appear, may prove disastrous. All those engaged in surgical work should make these details part of themselves as it were, and should cultivate what may be called the "antiseptic habit," so that its practice becomes second nature. Every one engaged in an operation must be equally alert to the necessities of absolute surgical cleanliness, for the success of the method demands that each should remember that the accomplishment of the aims in view depends upon the exertions and scrupulous attention to detail of surgeon, assistants, and nurses alike. In hospital practice it is too frequently assumed that the operating surgeon is responsible for success or failure, and thus laxity is encouraged; it cannot be too strongly insisted that dressers and nurses alike contribute to success if they follow strictly the antiseptic method, but court failure by neglect of the necessary precautions.

The materials employed and their disinfection[1]—

[1] Only those materials in common use, and which will be found to answer all ordinary purposes, are mentioned.

Solutions.—*Carbolic acid* solution, varying in strength from 1 to 5 per cent, is the antiseptic most usually employed. Five per cent is the proper strength for purposes of disinfection, but during an operation the hands, instruments, etc. should be immersed in $2\frac{1}{2}$ per cent, and weaker solutions are used for irrigating large wounds; absolute phenol should be alone employed in making the solution. *Sublimate solution* 1 : 1000 or weaker is used by many surgeons in preference to carbolic acid, the strength of the solution varying according to the purpose for which it is used. Mercurial solutions have the disadvantage of spoiling steel instruments, and hence carbolic acid is preferred by most surgeons. Watson Cheyne recommends 1 : 500 sublimate solution with 5 per cent carbolic acid added for cleansing the field of operation, a foul wound, and the hands. A solution of the *biniodide of mercury* (1 : 4000) is preferred by some; it has the advantage over the perchloride of not forming an insoluble and inactive albuminate.

Weak *iodine solution* (ʒii. ad Oi.) is useful in operations about the vagina and in cases where it is necessary to irrigate large cavities. *Condy's fluid* is an excellent antiseptic solution for mucous surfaces, and is much used in operations on the mouth, etc.

Boracic acid in saturated solution or diluted is quite unirritating and very useful for irrigating wounds. *Sterilised water* and *normal saline solution* may be used for the same purpose.

Ointments.—*Salicylic acid* and *boracic* ointments, made with the best paraffin, are useful to protect the skin against possible irritation from antiseptic gauzes. Boracic acid ointment makes an excellent dressing for superficial granulating wounds.

Sponges and mops.—Sponges should be of the best quality, and must be well shaken and immersed in water or dilute hydrochloric acid until they are freed of all grit. They are then thoroughly washed in hot carbolic solution with soap, rinsed, and placed in 1 : 20 carbolic solution for twenty-four hours before being used. Sponges are better not used a second time; but this plan is costly, and if properly cleansed they may safely be used again, after thorough washing and subsequent immersion in carbolic solution.

Most surgeons prefer mops made of absorbent wool enclosed in sterilised gauze, and placed in 1 : 20 carbolic solution for one hour before they are used, after which they are burnt. These mops should not be used in the abdominal or other cavities, as they sometimes fray and small pieces may be left behind. Before being handed

to the surgeon, sponges and mops are to be wrung out of 1 : 40 carbolic or 1 : 2000 sublimate solution.

Instruments.—Instruments made entirely of steel may be readily sterilised by boiling for ten minutes in a 1 per cent solution of the best washing soda, which assists in removing grease; they are then placed in 1 : 40 carbolic solution for the operation. If boiling is not resorted to, instruments should be thoroughly washed with soap and hot water, and scrubbed with a nail brush, which should be kept in 1 : 20 carbolic solution. Care must be taken to ensure perfect cleanliness of the teeth and catches of forceps, and other such parts of instruments in which dirt may lodge. After washing, they must be placed in 1 : 20 carbolic solution for half an hour, and may then be transferred to 1 : 40 for the operation. Should an instrument be fouled during an operation (as by falling on the floor) it must not be used again unless sterilised by boiling.

Ligatures.—*Catgut* being readily absorbable is, in this respect, an ideal ligature; but it is very difficult to sterilise, and when used should be obtained from a reliable source. The sulpho-chromic gut is the best, and should be kept in 1 : 20 carbolic solution, or placed in it half an hour or more before use.

Silk may be sterilised by boiling, or by immersion in 1 : 20 carbolic for twenty-four hours. It is the favourite material for ordinary ligatures.

Sutures.—*Silkworm-gut* and *horse-hair* are the best materials for sutures, and may be sterilised by boiling, or by being kept in 1 : 20 carbolic solution. *Silver wire* is but rarely used, and silk has the disadvantage of being absorbent.

Kangaroo-tendon is extensively employed in the radical cure of hernia, for the ligature of large arteries, and some other operations, and may be sterilised by immersion in 1 : 20 carbolic or 1 : 1000 sublimate solution; the tendons are best kept in absolute alcohol.

Drainage tubes of *vulcanised rubber* are those usually employed. Glass is sometimes used in the abdominal cavity. The tubes may be sterilised by boiling, or by keeping in an antiseptic solution.

In small wounds drainage may be secured by placing a few strands of *silk*, *catgut*, or *horse-hair* in the bottom of the wound.

Macewen's *decalcified bone* tubes are but little used; they are absorbed in about a fortnight.

Dressing materials.—Of the many antiseptic gauzes and wools which are made the best dressing is the double cyanide of zinc and mercury gauze and salicylic wool. The double cyanide is not decomposed by the discharge soaking into the gauze, and hence its

antiseptic properties remain unchanged. Gauze as a dressing material has the advantage of being soft, pliable, comfortable, and readily absorbent. Iodoform gauze is very useful for packing open wounds. Gauze is also impregnated with carbolic acid, corrosive sublimate, the double chloride of mercury and ammonium (sal alembroth), and other antiseptics. Of wools salicylic is the best, but has the disadvantage of causing irritation of the nasal mucous membrane when it is handled. Sal alembroth and iodoform wool are not much used; the latter is expensive.

Gauze and wool dressings may be sterilised by exposure to superheated steam for an hour, for which purpose various forms of apparatus are in use. After sterilisation the gauze should be damped with 1 : 20 carbolic solution, and kept wrapped up in jaconet. These materials should be kept in a tin box, which can easily be cleaned. Before use, the gauze is squeezed out of 1 : 20 carbolic or 1:2000 sublimate solution.

ASEPTIC OPERATIONS

Disinfection of the area of operation—Disinfection of the skin when no wound is present.—Before the time fixed for the operation, the area involved and the skin for some distance round must be thoroughly disinfected. All parts which the dressing may cover must be perfectly aseptic. If time permits, this should be done the night before, and repeated the morning of the operation. All hair is closely shaved off, the natural grease removed with ether or turpentine, and the part is thoroughly washed with soap and hot carbolic solution. A clean nail-brush (sterilised in carbolic) should be freely used to remove the dead epithelial scales, and special attention must be paid to natural folds and creases (*e.g.* the umbilicus) which may harbour infective material. After washing, the part should be dried with gauze, and covered with a pad wrung out of the strong carbolic or sublimate solution.[1] The pad is retained in accurate position by a bandage, and is not removed until the patient is anæsthetised. If the parts are very dirty, the washing should be repeated two or three times the day before the operation.

Disinfection of ulcerated surfaces and sinuses at the field of operation must be carried out for some days before the operation. The skin must be cleaned as above directed, and the foul surface

[1] Delicate skins will not tolerate the strong solutions, and these must be used proportionately weaker.

should be covered with a wet gauze dressing, changed twice daily. In bad cases the granulations should be treated with pure carbolic acid, 1 : 500 sublimate solution, or a solution of chloride of zinc, grs. 40 ad ℥i., and then covered with a gauze dressing. At the time of operation sinuses and granulating surfaces must be first freely sharp-spooned, and the denuded surface treated with strong carbolic or sublimate solution; the débris is carefully removed from the area of operation, and the wounds being plugged with gauze, the skin is finally washed and cleansed before any further steps are taken.

It has been suggested that when an operation is to be conducted under circumstances, *e.g.* a foul cancer, which may possibly lead to infection of the wound, that an attempt should be made to immunise the patient by the previous injection of anti-streptococcus serum; but few surgeons would deem this either necessary or right.

Disinfection of mucous surfaces.—Ideal antiseptic surgery cannot be ensured in the case of cavities lined by mucous membrane, but care and attention will accomplish sufficient to ensure a good result. In operations on the mouth the patient should frequently use a wash of Condy's fluid for some days before the operation, and if any sore is present, as in cases of cancer, the surface should be freely dusted with iodoform. Before the operation is commenced the mucous surface should be scrubbed over with 1 : 2000 sublimate solution.

The vagina should be freely douched with 1 : 5000 sublimate, Condy's fluid, iodine solution, or boracic acid, and the vulva must be thoroughly cleansed with soap and hot water. The canal should then be plugged with antiseptic gauze, and a piece should be placed over the vulva. At the time of operation the flushing is repeated, especial care being taken to wash out the cul-de-sac round the os uteri.

When it is proposed to open the bladder, it should be repeatedly washed out and treated with small injections of iodoform emulsion, if any cystitis is present. In the case of the rectum, douching with an antiseptic lotion similar to that used for the vagina will accomplish all that can be done. Chief reliance must be placed on the use of iodoform, and perfect cleanliness after the operation.

Disinfection of the surgeon's and assistants' hands is carried out in the same way as is that of the skin in the field of operation. The forearms should be bare, and thoroughly scrubbed. Great care must be taken to ensure cleanliness of the nails, where dirt is so liable to lodge. After washing, the parts are soaked in mercury or carbolic solution, in which the hands should be occasionally rinsed during the operation. Care must be taken that the hands, after

disinfection, are not fouled by touching anything which is not surgically clean—being thrust into the pockets and the like. If the surgeon has recently seen an infective case, the hands should receive extra attention.

The operation.—In hospital practice, when several operations have to be performed, all those cases in which there is no open wound should be first taken, and the foulest should be left until the last.

Complete disinfection having been carried out as previously described, the patient is placed in the required position, and the field of operation is isolated by towels wrung out of 1 : 20 carbolic or 1 : 2000 sublimate solution. The towels should extend for some distance round, so that all parts with which the hands or instruments may come in contact may be perfectly protected. The pad is now removed from the area of operation and the part finally well scrubbed with the antiseptic solution. The operation must be conducted with every care, and anything like tearing or lacerating the structures, whereby their vitality will be lowered and serous exudation increased in amount, must be avoided. No doubt a dexterous and gentle-handed surgeon will, other things being equal, achieve better results than one who is rough and bungling in his manipulations.

If the wound is a large one, part of it should be protected with gauze while the operation is being carried on elsewhere. The instruments not actually in use should be replaced in the carbolic solution, and none should be employed which have not been properly sterilised ; should an instrument be accidentally fouled, as by falling on the floor, it should be left there until the operation is completed, as it is unfit for further use, and if an assistant picks it up he will probably foul his hands.

From time to time the wound should be irrigated with a weak antiseptic solution (1 : 60 carbolic or 1 : 5000 sublimate); if strong solutions are used healing may be interfered with in consequence of the irritation excited, or at least the amount of serous exudate which occurs during the first few hours will be considerably increased. Water or normal saline solution, sterilised, do admirably for irrigation, and may be used at a temperature of 120°-130° F. ; this arrests capillary oozing, and if the patient is collapsed tends to materially improve the pulse.

Some surgeons, especially on the Continent, avoid irrigation and follow the dry method, contending that irrigation is quite unnecessary if due precaution has been taken to disinfect everything concerned in the operation, and, moreover, that antiseptic fluids

applied to raw tissues must necessarily prove irritating. Doubtless this is the ideal method, but in spite of theoretical objections practice shows that irrigation with weak solutions is not productive of harm, and as it possibly affords additional security, it is the wiser course to follow.

The arrest of hæmorrhage is very important and should be carefully effected. Divided vessels should be clamped and ligatured if necessary; if the forceps be left on the smaller ones for some time all bleeding will be found to have stopped on their removal, and there is no need to apply ligatures which at best must be regarded as foreign bodies.

Sterilised sulpho-chromic gut should always be used in operations of such a nature that union by first intention cannot be hoped for, *e.g.* cystotomy, since these ligatures become absorbed. When first intention can be ensured silk ligatures may be safely used, as they do not set up irritation if properly sterilised; but if suppuration should unhappily occur, the silk absorbs the discharge and may remain as a source of irritation for weeks until the ligature has separated.

Suturing the wound.—Perfect suturing should ensure accurate apposition of the edges of the wound with a minimum degree of tension. The strength of the suture and the distance it is inserted from the edge of the wound must vary with the tension. If, say after amputation of the breast, the edges of the incision readily come together, deep sutures of silkworm gut should be inserted at intervals of $1\frac{1}{2}$ inch; these must pass through the whole thickness of the flap about $\frac{1}{2}$ inch from the edge; between these deep sutures the wound is accurately united by horsehair sutures about $\frac{1}{3}$ inch apart, and passed deeply enough to secure a good deal of the surfaces being in contact. In many wounds, *e.g.* hernia, I use horsehair only and have never had reason to regret it. If the edges of the wound can only be brought in contact under considerable tension on the flaps, the button and silver wire may be used. The button should be separated from the skin by a layer of gauze, and these "sutures of relaxation" should be removed about the third or fourth day if they excite irritation. The interrupted suture is certainly the best, although it takes a much longer time to unite the wound than is necessary for the continuous suture. If a continuous suture is to be used silk is practically the only material available, and the button-hole method of introduction should be employed. The interrupted suture has the great advantage that each point of suture is independent of the others, and that if for

any reason it is necessary to open up one end of the wound a couple of stitches can be removed without interfering in the least with the apposition of the rest.

In some cases it is necessary or advantageous to completely adjust the deeper parts of a wound by the use of sutures which remain embedded in the tissues as do the ligatures (*buried sutures*). For this purpose sulpho-chromic gut or silk may be used; kangaroo tendon is largely employed for suturing the rings in the radical cure of hernia. In operations on the abdomen silkworm gut sutures should first be passed completely through the wall, and subsequently each layer of divided muscle is separately united with chromic gut; the deep sutures are then tied. It is essential that buried sutures should be absolutely sterile. Sutures should be introduced with Hagedorn's needles which have a knife edge at the point, so that when the suture is tightened the edges of the little wound made by the needle are approximated. Triangular needles and those with a cutting edge parallel with the edge of the wound should not be used.

If the edges of the wound cannot be brought together two courses are open to the surgeon: (1) he may at once graft the raw surface by Thiersch's method; or (2) may allow a film of blood-clot to form over the wound, and protect this with a piece of sterilised protective, outside which the usual dressing is applied. This method aims at inducing "organisation of blood-clot," and was introduced by Schede. It is a most useful mode of treatment in operations on bones. The dressings should remain untouched as long as possible. In ordinary wounds of the soft parts, as after amputation of the breast, immediate grafting of the raw surface gives excellent results. The part from which the grafts are taken must of course have been previously thoroughly disinfected.

Drying the wound.—By no means the least important element in antiseptic surgery is complete dryness. When the operation is completed and the wound is ready for dressing it should be gently but firmly compressed, so that all blood and clot may be expressed before the final sutures are united, and this pressure should be kept up by an assistant as each successive layer of dressing is applied and it is finally ensured by the bandage.

Drainage.—For a few hours after the infliction of a wound there is a certain amount of albuminous, serous discharge from the damaged tissues which serves as an excellent culture medium for micro-organisms, and it is of primary importance that this should be removed from the wound and absorbed by the antiseptic dressings.

The quantity of the discharge, and hence the necessity for the employment of tubes or other means of drainage is directly proportional to the size of the wound, the amount of damage inflicted on the tissues, the degree of irritation to which they have been subjected by the use of strong antiseptic solutions, and the facility the part affords for bringing all the damaged tissues into accurate apposition under moderate pressure.

In the case of clean incised wounds where all parts are easily adjusted, sufficient drainage will be afforded if about ½ inch of the wound at the most dependent part be left unsutured. When the wound is extensive or deep (as in clearing out the axilla), a drainage tube should be used for the first two or three days, when it may usually be safely removed, but it will do no harm if left for a longer period, so that there is no actual necessity to disturb the wound by dressing merely to remove the tube. A sterilised safety pin should be passed through one side of the tube to secure it against slipping into the wound, and the end should be passed through a slit in the first layer of gauze dressing, so that the discharge drains away from the wound. In draining large cavities the tube should be provided with a flange or may be passed through a metal shield of appropriate size. Small wounds may be readily drained by introducing a few strands of catgut, silk, or horsehair.

If in any case the propriety of drainage is doubtful, it is wise to err on the side of safety and adopt it.

Dressing.—A good dressing must fulfil the following conditions:—It must be soft, elastic, pliable, and easily adaptable to irregularities of surface; it must be readily absorbent and thoroughly sterilised, but must not be possessed of irritating properties. Before the dressings are applied the wound should be guarded by a layer of gauze, while the surrounding skin is finally cleaned with antiseptic solution. Layers of gauze wrung out of 1 : 20 carbolic or 1 : 2000 sublimate are placed over the wound extending beyond it for at least three inches in each direction, care being taken that a plentiful supply of gauze is placed in that position towards which any discharge will gravitate. The gauze must also be so placed and packed that all parts of the wound are brought into apposition and accurately compressed by the dressing, so that union by the first intention will occur throughout. Some surgeons use a piece of oiled silk protective beneath the gauze to prevent any irritation by the antiseptic; if used it must be quite small and merely cover the line of incision and sutures. Outside the gauze a thick layer of salicylic wool is placed with the same precautions as to packing—the wool must

overlap the gauze for about three inches, and is then firmly bandaged on.

In the case of wounds from which much oozing may be expected I usually use a quantity of powdered boracic acid between the outer layers of gauze. For small and comparatively superficial incised wounds a simple layer of salicylic wool fastened on with flexible collodion is all that is necessary. I frequently use such a dressing in cases of varicocele, hernia, or the removal of small tumours, and have never had any subsequent trouble.

In operations on mucous cavities asepsis must be ensured by plugging with iodoform gauze which must be changed every day or oftener, or by frequent irrigation with Condy's fluid or some mild antiseptic solution. Iodoform is especially useful, and should be lightly dusted over the surface.

After-treatment.—When the case has once been dressed the less it is disturbed the better, for complete rest is essential to the healing process.

The period at which the wound should be dressed necessarily varies with circumstances, but in ordinary cases the dressings may remain untouched for ten days when the wound will be found completely healed; the sutures should be taken out, and the scar may be protected for another week by a thin layer of salicylic wool fastened on with collodion.

Earlier change of dressing may be advisable or necessary under any of the following conditions:—

(1) *For the removal of a drainage tube.*—When a tube has been employed it may usually be safely dispensed with on the third day, but there will be no harm in leaving it longer, and if the patient is nervous of being dressed, or complete rest is very desirable, the tube may well be left till the end of a week or ten days.

(2) *If the discharge comes through the dressing.*—The occurrence of this should be carefully watched for by the nurse, who should be instructed to "pack" the dressing at once so that contamination is avoided pending the application of a fresh dressing. Packing should be done as follows—a pad of gauze is placed over the dressing where the discharge has come through, and over this a layer of salicylic wool is lightly bandaged.

It is advisable to dress the wound as soon afterwards as possible.

(3) *If the patient exhibits constitutional febrile symptoms* indicative of the presence of pent-up serum, of septic intoxication, or some other morbid process occurring in the wound.

Under these circumstances the dressings should be at once removed and the wound examined; if there is evidence of pent-up serum, one end of the wound should be gently opened up with sinus forceps, the serum let out, and a small drainage tube inserted for a couple of days. If there is septic intoxication or some more serious condition, the wound should be gently irrigated with weak antiseptic solution, and if there is suppuration with decided inflammation, hot boracic fomentations must be substituted for the dry dressing.

(4) *If the dressing causes the patient great discomfort* it may be changed, for it is sometimes very difficult to apply a large dressing to an unconscious person so that it will be really comfortable. For very fat patients I usually change the dressing about the third or fourth day, for they are especially difficult to dress comfortably, and, moreover, they sweat a good deal under a wool dressing. Dressings require more frequent changing during the hot weather.

Method of re-dressing.—The parts are completely isolated with carbolised towels as at the time of operation, and the same precautions are taken as regards the hands, etc. The outside dressing is removed, and then the layer of gauze next the wound is gently taken off and quickly replaced by a fresh piece, so that the wound is not exposed more than necessary. The dressing is completed in the usual way. The wounds should not be irrigated unless the antiseptics have failed and there is pent-up foul discharge; but if any oozing has taken place, the line of union may be covered with a piece of gauze while the surrounding skin is gently cleansed.

ANTISEPTIC TREATMENT OF ACCIDENTAL WOUNDS

Precisely the same method of treatment is applicable to accidental as to surgical wounds, but in the former much greater care is needed, since the wound is too frequently begrimed with dirt and already infected. Moreover, the contusion and frequent laceration of accidental wounds render them very liable to inflammation and sloughing. The liability to contamination depends upon the seat of the wound, but more upon the circumstances under which it was inflicted.

The disinfection of the hands, instruments, etc., is carried out as already described.

Disinfecting the wound and parts round.—When the hæmorrhage has been arrested a stream of dilute antiseptic fluid

(1:40 carbolic, 1:5000 sublimate) should be allowed to run over the wound from one end to the other, so that any loosely adhering dirt may be at once got rid of. The wound is now plugged with gauze, while the surrounding skin is thoroughly disinfected by washing, etc., as described on p. 5. When this has been done, the gauze is removed and the wound carefully examined to ascertain its nature and extent and the damage done to the individual structures. The examination should be made with the finger. If necessary the wound must be enlarged and the patient anæsthetised.

When the wound has been fully exposed it must be thoroughly cleansed with 1:20 carbolic or 1:1000 sublimate solution. In the case of clean-cut wounds this can be easily done by mopping away the blood-clot and allowing a stream of the fluid to run over the surface.

In lacerated and contused wounds in which the tissues are often very foul (*e.g.* scalp wounds, p. 231) great precautions are necessary. The tissues may be cleansed by free rubbing with a rough sponge, and if very much damaged and begrimed with filth the affected part should, unless it is of vital importance, be cut away with scissors. It is essential that no part of the wound should be left uncleansed; to reach the deeper parts a syringe armed with a piece of india-rubber tubing, which can easily be insinuated among the torn tissues, should be used, but every facility must be afforded for the free escape of the fluid injected, or it may be forced among the cellular planes.

Suturing.—The propriety of employing buried sutures of chromic gut or silk for uniting deeper structures which have been divided must be determined on the merits of each case. Divided nerves and tendons must always be sutured. The question of closing the wound wholly or in part has also to be determined. Clean-cut wounds may be safely treated by immediate suture without drainage just as in the case of a similar wound made by a surgeon.

Contused and lacerated wounds, especially if they have been fouled, should not be approximated by sutures throughout, but a part must be left open at a convenient position to allow of free drainage. It is a good rule to follow in practice that if the propriety of using sutures is doubtful they should not be employed; more harm is likely to arise from their injudicious use than from their unnecessary abandonment. If sutures are not used the wound should be lightly packed with gauze, which should be changed sufficiently often, and when granulation is established may

be replaced by a simple dressing of red wash or boracic acid solution.

Drainage.—The remarks made as regards the employment of sutures apply equally to drainage. Clean-cut unsoiled wounds do not require it unless they are deep and large, but contused and lacerated wounds must always be drained freely. Such wounds from their very nature always exude a considerable quantity of serum, which is increased by the irritation caused by the necessarily energetic use of strong antiseptic solutions. The drainage tubes should remain in until the discharge is very slight, and if suppuration occurs, until the wound is quite superficial.

Dressing and after-treatment.—The method of dressing as prescribed for operation wounds is also applicable to those of accidental origin, and the after-treatment is similar.

It not infrequently happens that punctured, contused, and lacerated wounds (especially about the hands where contamination is so common) inflame and suppurate, and portions of contused tissue may slough or cellulitis may extend from the injury. Under such circumstances the employment of hot antiseptic fomentations, of the antiseptic bath, or of continuous irrigation must be enforced. Irrigation with weak boracic solution at a temperature of about 100° F. is most useful when the wound is so placed that the arm-bath cannot be used; no doubt irrigation gives some trouble in carrying out, but the results are proportionately satisfactory. The fluid should be allowed to run over the part in a gentle stream which causes no pain or inconvenience to the patient. Irrigation keeps the wound quite clean, washes away the albuminous discharge, and thus removes material in which micro-organisms might develop and thrive. Whichever form of application is used, it should be persevered with until all inflammation has ceased, the sloughs have separated, and the wound is granulating healthily. If cellulitis occurs the treatment of that condition must be adopted (see chap. vii. vol. i.).

CHAPTER II

Injuries and their Effects—The Healing of Wounds

CONTUSIONS

Definition and etiology.—By the term contusion is meant a laceration of the subcutaneous or deeper structures of a part without any wound of the skin.

Contusions usually result from severe blows or falls, but may be due to pressure only, *e.g.* caput succedaneum. Indirect violence may occasion bruising and contusion of distant parts, as in the case of a fall upon the outstretched hand causing bruising of the shoulder joint, or of contusion of the brain in head injuries. Contusions of the abdomen or chest may cause bruising or laceration of the contained viscera.

Morbid anatomy.—The amount of damage inflicted on the tissues depends upon the force of the violence producing the contusion, the natural resilience of the part involved, and the general state of the tissues. Some people, especially women, the aged, the obese, and those in weak health, bruise very readily, a point worthy of note in the performance of operations so that the utmost gentleness may be observed.

A contusion may be very slight, causing nothing more than an ordinary bruise, or may be so severe that muscles, nerves, vessels, and bones are reduced to a pulp, the skin alone, on account of its elasticity and toughness, remaining intact. In the worst cases the tissues may be totally disorganised. The damage inflicted by rupture of some of the vessels causes an escape of blood and bloody serum into the tissues. The amount of hæmorrhage varies with the size and number of the vessels injured, and with the previous state of their walls. The blood may be diffused among the tissues,

the direction being determined in many cases by the muscular and fascial planes, or it may remain localised, giving rise to a hæmatoma.

The effused blood causes more or less discoloration of the tissues, and swelling, which is increased by bloody serous exudate from the damaged vessels, especially from the thin-walled veins.

The ultimate results of a contusion depend upon its degree and the previous vital state of the tissues, being necessarily more serious if they are the seat of disease or diminished vitality. In a slight case, such as a simple bruise, the blood and exudate are quickly absorbed, and the discoloration, becoming first mottled and then greenish or yellowish in colour, disappears, the part suffering no permanent ill-effect. The colour changes in the effused blood do not occur in the deeper structures, but only in parts exposed to light.

In more severe contusions a certain amount of induration of the part occurs, causing stiffness which may remain for a long time. In the worst cases the vitality of the tissues may be so impaired that sloughing or gangrene follow, or suppuration takes place in the neighbourhood of the blood-clot which acts as a foreign body.

Blebs containing blood-stained serum not infrequently form on the skin of contused parts, and their appearance may suggest the onset of moist gangrene, an error which is easily avoided by a little care; when blebs form in gangrene there is loss of heat and sensation over the affected area. Contusions of muscles or nerves may lead to partial or complete paralysis and wasting—happily, in the majority of cases, of a temporary nature only. This is by no means uncommonly seen in the deltoid and scapular muscles after a fall upon the shoulder.

Contusions of nerves may induce neuritis and continued pain (p. 136).

The effects of contusions of internal organs will be referred to in Injuries of the Abdomen and Chest.

Signs.—The chief signs of a contusion are swelling and discoloration from effused blood, with some pain and stiffness. The swelling is, other things being equal, greater in lax tissues. If the effused blood is in considerable quantity and localised, pressure will elicit the peculiar sensation of blood-crepitus. Severe bruising round a joint may simulate fracture or dislocation from the position assumed by the injured limb; careful examination, under an anæsthetic if necessary, will determine the true nature of the case.

Treatment.—In the milder forms of bruising the application of cold evaporating lotions or the ice-bag is all that is necessary.

Cold must be judiciously and not over-zealously employed, or it may lower the vitality to such a degree that inflammation and sloughing are induced. Cold acts beneficially by arresting the escape of blood and lessening the amount of exudation.

When the hæmorrhage is considerable and a hæmatoma forms, no attempt should be made to remove the blood. If this is done there is the possibility of introducing septic material, and thereby exciting inflammation and suppuration. Moreover, removal of the blood may, by taking off pressure from the injured vessels, lead to additional hæmorrhage.

In more severe contusions, when the injury is such that inflammation and sloughing are apprehended, the application of warmth, either in the form of fomentations or swathing in cotton wadding, combined with mild purgation and unstimulating diet, forms the most appropriate treatment.

When the limb is completely pulped, amputation is required.

WOUNDS

Varieties.—A wound is a solution of continuity of the tissues due to injury.

A wound is said to be *open* when the skin is implicated, *subcutaneous* when it is intact, as in rupture of a tendon or a simple fracture. When the skin wound is very small, as in the case of tenotomy, the injury may practically be considered subcutaneous. Open wounds may be *incised*, *contused*, *lacerated*, or *punctured*, according to their cause, but in many cases wounds present a combination of these characters; thus all lacerated and most punctured wounds are also contused. A wound may be *poisoned* either from the essential nature of its cause, *e.g.* snake-bite, or from being inflicted by a dirty instrument.

Incised wounds are the most common, and are produced by sharp instruments; or in some cases by a severe blow over a bone, such as the crest of the tibia, the sharp edge of which cuts through the skin.

The amount of gaping of an incised wound varies according to the natural elasticity of the part involved, and the direction of the incision; in the limbs, for example, the gaping is wider if the cut passes transversely to the long axis, *i.e.* to the direction of the muscles. The amount of hæmorrhage depends upon the number

and importance of the vessels wounded, and, *inter alia*, on the proximity of the heart. If a vessel is only partly divided it is unable to retract, and the bleeding will be proportionately severe. Pain is usually of a burning character, and is naturally more acute in highly sensitive parts and in persons of a nervous temperament. In the case of wounds, even severe ones, inflicted during great mental excitement, no pain may be experienced, and indeed the wound itself may be unnoticed until the excitement has passed off (see p. 40). Incised wounds, if not inoculated with septic material, and if the patient be in good health, heal rapidly by first intention under appropriate antiseptic treatment.

Contused and lacerated wounds have many points in common, and from a practical point of view are better considered together. They can be produced by blunt instruments, circular saws, gun-shot and railway accidents, explosives, and the claws and horns of animals.

Such wounds are often extensive. They are irregular and torn, with jagged edges, the tissues being much bruised, and portions sometimes almost completely separated; muscles may be torn away at their attachments, and vessels and nerves stretched and lacerated, the skin being sometimes widely separated from the deep fascia. The amount of hæmorrhage, even when large vessels are injured, is often slight, since the elastic vessels are stretched and dragged out of the tissues, the middle and inner coats rupture and retract within the outer, which becomes twisted, thus preventing the escape of blood (*natural torsion*).

Contused and lacerated wounds often slough, and suppuration may extend widely; gangrene may result either from injury to important vessels, or as the direct effect of the pulping of the tissues. The irregularity of these wounds favours the retention of dirt and foreign bodies and the accumulation of discharges; hence, unless strict antiseptic precautions be taken at the outset, decomposition may occur, and septic and infective processes result.

Contused and lacerated wounds heal by granulation.

Punctured wounds are produced by pointed instruments. If the instrument be blunt the wound is proportionately more serious, as there is more associated contusion. A punctured wound, however small, may be of a serious nature, since it may open up one of the body cavities, or wound a joint or large blood-vessel; or, again, a portion of the instrument inflicting the injury may be broken off and remain as a foreign body in the bottom of the wound. Punctured wounds do not gape, and often appear very trivial, the wound closing at once; consequently foreign bodies

and discharges are liable to remain pent up in the deeper parts, giving rise to intense inflammation and suppuration, especially if septic material has been introduced. A good example of this is seen in the case of small wounds of the fingers leading to diffuse inflammation of the palm and forearm.

The Effects of Injury

Apart from changes which may occur in a wound from circumstances peculiar to the patient or his surroundings, certain constitutional conditions may arise as the direct and immediate result of an injury. The occurrence and severity of those states depend partly on the nature and seat of the injury, and partly on the constitution of the patient.

SHOCK OR COLLAPSE

Shock is the term applied to an assemblage of symptoms dependent on extreme nervous prostration, with depression of the heart's action, induced by severe injury or by powerful mental emotion alone. Syncope and shock are closely allied, if not identical conditions, differing only in degree. The severity of shock varies within the widest limits, from a transient feeling of faintness to sudden death.

Causes.—Moral, in addition to physical causes, play no mean part in the production of collapse. That the mental state and temperament of individuals is a powerful causative factor is well known to all. Strong emotions, such as fright, have not infrequently caused death attributable to shock alone, and doubtless in the case of injury the resulting shock is deepened by the effect made upon the mind. The circumstances under which an injury is inflicted materially influence the occurrence and degree of shock; thus, in injuries received during times of great mental excitement, *e.g.* in battle, the shock is very slight at first, but, although delayed, is usually more severe when it makes its appearance after the excitement has passed off, such excitement having itself partly exhausted the nervous centres. If, on the other hand, a person has, as in the case of a capital operation, looked forward with dread and apprehension to its performance, shock occurs early and is marked.

Neurotic and highly sensitive persons, the aged, and the very young suffer more from shock than do the phlegmatic and more robust, the latter possessing more reserve nervous energy.

The weakly and those who are the subjects of chronic visceral disease, especially renal, are very likely to suffer severe shock from even slight causes; on the other hand, those who, being otherwise healthy, have, from the nature of their ailments, been confined to bed for a long time, and whose general strength is impaired, are to a certain extent protected against shock. This is well exemplified in the case of primary and secondary amputations. The degree of shock is much influenced by the superficial extent and situation of the injury. Other things being equal the greater the surface area of the wound the greater the shock. Burns involving a large surface are accompanied by extreme collapse, no doubt increased by the terror and pain attending the injury.

Injuries of the abdomen and viscera, of the testes, perforation of the intestine or stomach, the passage of instruments down the urethra, and injuries of the head are especially apt to cause marked collapse.

Pain, hæmorrhage, and exposure to eold are powerful concomitant causes of shock, and during the performance of any operation should be reduced to a minimum.

Pathology and morbid anatomy.—That shock is dependent upon exhaustion and prostration of the nervous centres eonsequent on powerful impressions on the brain and peripheral nerves is beyond doubt. The heart is profoundly affected through the inhibitory fibres of the vagus, and if the stimulus be strong enough its action will be arrested in diastole, and sudden death occur; in less severe cases the action of the heart is only temporarily depressed, and is subsequently augmented during the period of reaction. *Post-mortem* examination of fatal cases of shoek reveals very little. The heart, arrested in diastole, is engorged with blood, the right side being especially full. The brain is anæmic, while the general venous system, notably that of the splanchnic area, is engorged with blood; indeed, a patient dying of shock may be said to bleed to death into his venous system. This engorgement is due to nervous inhibition with dilatation of the vessels, and to the weakened action of the heart. The blood usually coagulates poorly. Rigor mortis is well marked.

Symptoms.—As the degree of shock is subjeet to wide variation, the symptoms are correspondingly modified, varying, however, in degree rather than kind. The more important the organ injured the more severe are the symptoms of shock. In a well-marked case the patient lies upon his back, sunk down in the bed. The face is expressionless, the features wan and pinched, and there is

extreme muscular feebleness, evidenced by tremulousness of the hands and tongue, by relaxation of the sphincters, and inability to move. Consciousness is not usually lost, but there is marked mental lethargy; the patient speaks in a low though distinct voice, taking some time to collect his thoughts, and being incapable of any prolonged mental effort.

The skin is pale and cold, and often bathed in a profuse sweat, the mucous membranes are blue and cyanosed, and the temperature subnormal, sometimes as much as 4° F. The respirations are shallow, and may be hardly noticeable; the pulse is frequent, small and flickering, or even imperceptible; it is often irregular in force and rhythm. In the worst cases the general appearance is that of death. The condition may gradually deepen and prove fatal, or reaction may set in, usually within a few hours, but often requiring some days for complete recovery. The **stage of reaction** is usually ushered in by vomiting, and an inclination on the part of the patient to shift his position—evidence of returning muscular power and a sign of good augury. The pulse becomes more regular and increases in strength; respiration is deeper, stronger, and sometimes sighing; the skin becomes flushed and warm, and the temperature rises, perhaps reaching one or two degrees above the normal. The process of recovery from shock may be uninterrupted, but in some instances there are temporary remissions, while in others there is marked nervous excitement, with sleeplessness, perhaps delirium, convulsions, or coma. Such cases are of great gravity, and the patient usually succumbs from profound exhaustion. Even after severe shock there may be no permanent ill effects; but in some cases—and those not by any means always the worst—the general health of the patient suffers. There may indeed be no organic mischief present, but the patient never quite recovers his former energy and health, the resisting power is diminished, memory is often impaired, the hair turns gray, and, to use a common expression, "The man is not the same as he was." Organic disease, which was perhaps present in a slight degree, and therefore unnoticed before the occurrence of shock, may receive an impetus in consequence of the disturbed nervous condition.

Treatment—**Preventive.**—The preventive treatment of shock is a matter of the utmost importance to the operating surgeon. For some days before the performance of an operation likely to be attended by shock the patient should be kept quiet, preferably in bed, the bowels and kidneys should be regulated, and the diet should be nourishing, but not over-stimulating. The patient's mind should

be distracted from dwelling on the coming operation; he should be reassured as to its success, and the dread—natural on such occasions—should be lessened as much as possible. There is no worse patient than he who makes up his mind beforehand that he shall suffer severely from the effects of an operation, and has great misgivings as to the result. Before the performance of any capital operation it is a good plan to inject into the rectum about an ounce of brandy with hot water. Undue exposure and cold must be avoided. In these days of general anæsthetics operations are often unnecessarily prolonged, and it cannot be too often insisted that all operations should be conducted as expeditiously as possible. The sooner the patient is comfortably placed in a warm bed the better.

A hypodermic injection of morphia at the conclusion of an operation, especially if there is likely to be much pain when the effects of the anæsthetic have passed off, is a valuable means of diminishing shock; its use is contra-indicated in children and the subjects of renal mischief.

Curative.—A patient suffering from shock should be put to bed between blankets, and warmth should be kept up by the application of hot bottles wrapped in flannel to prevent blistering of the skin. Warmth and friction over the cardiac area are often beneficial in strengthening the heart's action. If such action be very feeble, and there is much fulness with distension of the jugulars, bleeding may be advisable, but the necessity for this is very rare. Artificial respiration should be persevered with even in apparently hopeless cases, if no respiratory movement can be detected.

Stimulants, especially ammonia, brandy, and champagne should be given in small quantities every half-hour, according to the effect produced on the pulse. In cases where there is vomiting or difficulty in deglutition, stimulating and nutrient enemata may be given, or ether may be injected subcutaneously. When reaction sets in, quiet should be observed, and the patient judiciously stimulated and fed. Restlessness and want of sleep demand the exhibition of opium, preferably by hypodermic injection. If severe hæmorrhage has occurred, transfusion of saline solution is requisite, and will be followed by rapid and marked improvement. Reaction with excitement must be treated on the same lines, opium, food, and stimulation being the chief indications.

Shock due to an injury necessitating surgical interference should, as a rule, be allowed to pass off before any operation is performed; in some cases, however, the presence of the injured part seems to

deepen and prolong the shock, and its removal should then be accomplished as soon as possible.

SIMPLE OR ASEPTIC TRAUMATIC FEVER

By simple traumatic fever is meant that elevation of temperature and constitutional disturbance which follow usually, but not constantly, on an injury; which are the direct result of that injury, and are independent of any septic or infective poisons accidentally introduced. Traumatic fever is best studied in cases of simple fracture in which there is no question of septic absorption. It occurs more constantly, and is more marked in the young and aged, in those of enfeebled health or neurotic disposition, and is proportionately more severe in serious injuries. In the case of open wounds it may be complicated by symptoms dependent upon septic causes, which have been fully considered in vol. i.

Course and symptoms.—The simplest and most usual type of traumatic fever comes on suddenly, as soon as the shock of the injury has passed off. The temperature reaches a maximum of about 101° F. in twenty-four hours, and may then decline to the normal within forty-eight, or remain up until the end of the first week. The constitutional disturbance is often so slight as to be hardly noticeable, slight headache, anorexia, and thirst being the most prominent symptoms. In injuries accompanied by much swelling and œdema the course of the fever is often somewhat different. The rise of temperature is more gradual, the maximum of 101° F. is reached in about forty-eight hours, after which there is a gradual decline to 99° F. by the eightieth hour, followed by a secondary rise to about 100° F. by the 112th hour, and a return to the normal in the course of three or four days or a little later. Other things being equal, the greater the amount of swelling the higher the fever, and the more marked the constitutional disturbance. These two forms of traumatic fever differ only in degree, not in actual causation, the difference being due to the greater amount of exudate and absorption, and the greater stimulation of nerve fibres in the more serious injuries.

Pathology.—Two distinct causes are probably at work in the production of simple traumatic fever. Consequent on any injury there is some extravasation of blood into the tissues, and it has been proved experimentally that serum, when absorbed, is a highly pyrogenic substance. Absorption of serum, then, with its fibrine ferment, is no doubt responsible in some measure for the resulting

fever, which—be it remembered—is always higher if the exuded serum is pent up in a tightly-stitched wound, and also in cases where the amount of bruising has led to considerable exudation and œdema.

Irritation of the nerves at the seat of injury probably also plays a part in the process. We know that *strong* stimulation of sensory nerves diminishes the temperature of the part, but *mild* stimulation increases it. The stimulus applied to the nerves is probably conveyed to heat centres in the cord, whereby their regulating mechanism is thrown out of gear, and fever results. Tension in a wound increases the degree of traumatic fever, partly by favouring the absorption of serum, partly perhaps by stimulating the nerves.

Prognosis and treatment.—Simple traumatic fever need never give rise to anxiety; it runs a definite course with but slight constitutional disturbance, and subsides without producing any ill effects upon the patient or retarding the healing of the wound. As regards treatment, this is rather preventive than curative; if from the nature of any accidental or surgical wound much serous exudate is expected, adequate drainage should be provided; if the fever runs high, as it may sometimes do, the dressings should be removed and any accumulated serum evacuated. Inflammation and œdema should be kept in check by rest or elevation, or such other means as are applicable to these conditions, having due regard to the nature and situation of the injury.

TRAUMATIC DELIRIUM—DELIRIUM TREMENS

Causes.—Those who have habitually taken an excess of alcoholic stimulants, or whose nervous system is from other causes in a depressed condition, are liable, after injury or surgical operation, to suffer from nervous traumatic delirium. Rarely occurring in those of temperate habits, the condition is, from a clinical point of view at least, identical with delirium tremens, and must not be confounded with the delirium accompanying inflammatory or septic processes which may attack the wound. In this connection it must be remembered that, in the intemperate, wounds frequently become the seat of morbid processes which may induce general constitutional disturbance accompanied by delirium. Traumatic delirium is essentially a condition of nervous prostration, and is therefore more likely to set in and to run a severe course if much shock has resulted from the injury.

Symptoms.—The symptoms usually make their appearance about the third day, or perhaps earlier; the onset often occurs at night and may be quite sudden, or may have been preceded by restlessness, mental anxiety, sleeplessness, and agitation. The disease is characterised by symptoms which there is no difficulty in attributing to their right cause. The patient is wakeful and extremely restless, nervous and excitable. It is with difficulty that he is induced to keep still for more than a moment, alternately sitting up in bed and lying down, pulling the clothes up or pushing them off, and frequently attempting to get out of bed. He seems as if impelled to be doing something but with no fixed purpose in view, adopting one method of exhibiting his restless agitation only to cast it aside in favour of another, which is as rapidly supplanted. Unless carefully watched he may tear off his bandages and splints, seemingly quite unconscious of pain. His manner is excited, he talks volubly, but can be rational if spoken to quietly, only to relapse in a few moments. There may be wild mania, but more usually there is low, muttering, busy delirium. The patient is suspicious of those around him, and of others whom his excited imagination conjures up. He suffers from delusions, often of a terrible nature, which inspire him with uncontrollable fear. Snakes, lizards, imps, and similar things appear to him to surround his bed or crawl over his body, and in the extremity of fear he begs the nurses to keep them away. In other cases the hallucinations are of a less terrifying or even of a pleasing nature.

Muscular tremor is a prominent symptom; the muscles are never still, the patient is constantly moving, and all his movements betray great nervous agitation.

The bowels are confined, the tongue flabby, tremulous and coated, and the breath offensive. There is often great thirst, with anorexia; the stomach also is intolerant of food, the digestive powers being at the lowest ebb. The pulse is rapid, soft, and small; the skin covered with sweat. The temperature is usually normal or but slightly raised unless there is any inflammatory action in the wound; its rise to any height is an unfavourable sign.

Prognosis.—The prognosis of traumatic delirium is usually good, depending in the main upon the strength and general health of the patient, and upon freedom from complications. Sometimes death occurs within twenty-four hours, but generally the fatal termination is more gradual and is due to exhaustion. If sleep cannot be obtained, or if the amount of food assimilated is insufficient, the gravity of the case increases. In mild cases, when

sleep has once been procured, the patient may wake up practically well.

Treatment.—The treatment of nervous traumatic delirium consists in restoring that tone to the nervous system, to the loss of which the disease is attributable. To attain this object there are two essentials—sleep and food. At the onset a dose of calomel or blue pill should be given to clear the bowels, and should be followed up by mild doses of some saline aperient. To procure sleep the patient should be kept by himself in a quiet darkened room, and the attendants should endeavour to soothe rather than forcibly restrain him. Morphia, bromide of potassium, and chloral are the sedatives usually employed, and must often be given in considerable quantities, repeated at intervals, before much effect is induced. Bromide of potassium in 30 or 40 grain doses, mixed with 10 or 15 grains of chloral, is most useful, and may be repeated every three hours if necessary. Morphia and opium sometimes increase the excitement, and should be used with great caution if renal mischief is present. Sulphonal and trional (ten grains of each) sometimes succeed in inducing sleep, and give good results. Solid food is useless since the patient is unable to digest it. Milk, beef-tea, eggs, chicken-broth, and similar nutriment should be given frequently in such quantities as the patient seems capable of digesting. The desirability of giving alcohol must be determined on the merits of the case; if the pulse be good, and the patient's strength fairly maintained, it should be withheld; but when there is marked exhaustion it becomes absolutely necessary, and should be given with food in such quantities as the state of the pulse may indicate. Cardiac failure may also be combated by the judicious use of digitalis or strychnine.

The excited movements of the patient should be controlled firmly but kindly, any roughness or harshness on the part of the nurse or attendant only tending to increase the excitement. If it becomes necessary to forcibly restrain the patient, it is better to put him into a straight waistcoat than to engage in a personal struggle with him.

Care must be taken that in his delirium he does no further damage to the part injured.

The Repair of Wounds

The process of repair of wounds is, so far as the minute changes are concerned, essentially the same under all conditions. The nature

and character of a wound influence to some extent the rapidity of the healing process and its clinical appearances, but in no way do they influence the steps necessary for the production of scar tissue. Clean-cut wounds treated antiseptically, and the edges of which have been carefully approximated by sutures, rapidly unite by what is known as "first intention"; those involving loss of substance, or which, from some cause, have not healed by first intention, do so by granulation or "second intention." In most cases granulating wounds heal from the bottom, but under favourable circumstances two granulating surfaces may unite. Superficial wounds, such as abrasions or scratches, heal under a scab. Clinically, then, we recognise these four methods of repair; they differ only in the appearance of the healing wound, not in the minute processes occurring, which are as follows:—The infliction of a wound entails a certain degree of lowered vitality in the tissues involved, and no doubt in all cases some cells perish. The immediate result of this lowered vitality is inflammation, but of a slight and transient nature only, provided the wound be kept free from irritating agents. The degree of inflammation is so slight that, clinically, it is scarcely recognisable. The divided vessels are occluded by blood-clot up to their next branches, the collateral vessels dilate, and lymph and leucocytes, escaping from these, infiltrate the edges of the wound, serving as a temporary bond of union between them if they are approximated. In the case of an open wound, the exudate forms a film on the surface, giving it a glazed appearance, while the serum, separated in the process of coagulation, drains away. In the light of present research we must regard this traumatic inflammation as a conservative and curative effort of nature, as we formerly did, but from a different standpoint. Cohnheim and his followers held the view that the new scar tissue was developed directly from the escaped leucocytes; but recent research, in this country especially by Ballance and Edmunds, has shown that the connective-tissue cells are responsible for the new tissue.

At the same time the escaped leucocytes play a by no means unimportant part in the chain of events. Those cells which have been killed outright by the injury, together with the blood-clot between the edges of the wound, are inert and waste material; and it is to the phagocytic action of the escaped leucocytes that their removal is due, and the path is thus cleared for the building up of scar tissue.

Soon after the invasion of the wound by leucocytes, other cells make their appearance. These are the so-called fibroblasts or

plasma cells, and they are derived from the connective-tissue cells. From leucocytes they may be readily distinguished by their larger size, coarser granules, and single, clear oval nucleus; no intermediate forms between the two kinds of cells were ever seen by Ballance and Edmunds. The plasma cells present great diversity of form, many of them being spindle-shaped and arranged in cords, others branched, tri-radiate, or multi-radiate; very few are round.

Multinuclear giant cells, formed by the fusion of plasma cells, are also found; other cells are vacuolated, while many contain the granular débris of leucocytes or red cells, which have in their turn been assimilated by the plasma cells, which are identical with the macrophages of Metchnikoff. Ballance and Edmunds, experimenting with Ziegler's chambers, introduced into the subcutaneous tissue of the guinea-pig, found that within twelve hours the leucocytes had congregated, forming cell-islets intermixed with fibrin; in eighteen hours plasma cells were numerous, and much more so in seventy-two. The plasma cells surround the leucocytes, being found in eight days; these, uniting by their branches and processes, form a membrane of anastomosing cells separated by intercellular substance, probably derived by a process of active secretion from the plasma cells themselves. The intercellular substance increases in amount and becomes fibrillated, thus producing new fibrous tissue, while some of the plasma cells remain as fixed connective-tissue corpuscles. That new scar tissue is formed from the progeny of the connective-tissue cells, and not from inflammatory leucocytes, is now conceded by most leading pathologists; but while connective-tissue cells are capable of forming fibrous scar tissue, they are quite incapable of repairing the more complex tissues, such as epithelium, muscle, and nerve, which are repaired by changes taking place in the cells of each tissue; hence ordinary scar tissue, although it is vascularised in the manner to be immediately described, is devoid of all higher tissues, except that it is covered by a thin layer of epithelium.

For the formation of perfect scar tissue it is essential, first, that there should be no undue degree of inflammation, and secondly, that new vessels should be formed to feed the newly-born formative cells. New vessels arise early in the growth of the scar, and are formed from the walls of old ones, from which lateral buds and projections are developed. These processes are at first solid; they continue to grow in length and thickness, nuclei appear among the granules, and anastomotic loops arise by fusion of adjacent processes, the central parts of which, as development proceeds, undergo lique-

faction, and the new vessels receive blood from the parent capillaries. Secondary loops spring in a similar manner from the primary ones. The new vessels increase in thickness and stability by an increase in the amount of protoplasm and multiplication of the cells. They are additionally strengthened by the cells of the developing scar-tissue.

Characters of and changes in scar tissue.—A recently formed scar is composed of succulent, highly vascular, fibrous tissue, but is devoid of more complex structures, such as sweat or sebaceous glands, and hair-follicles. The new vessels give it a bright red colour; but some of these, necessary during the growth of the scar, but no longer needed in such numbers to keep it alive, undergo atrophy, and the scar turns white—whiter than the surrounding skin—so that in time it is less noticeable, and may, if small, be scarcely recognisable in the course of years. Contraction is an inherent quality of all scar tissue, and, as granulation proceeds, plays an important part in the healing process, considerably diminishing the area of the wound. In rigid parts, where contraction can only take place to a small extent, a wound takes proportionately longer to heal.

In consequence of contraction, a scar occupies a much smaller area than the original wound, and it becomes slightly depressed in the centre; contraction may, however, lead to more or less serious consequences, either from its amount or from the situation of the scar. In severe burns, extending to the subcutaneous tissue, contraction may be so great that serious and lasting deformity results (Fig. 1). Scar tissue forming round a tube, or within its walls, leads to stricture of its lumen, followed by changes in the parts behind the obstruction.

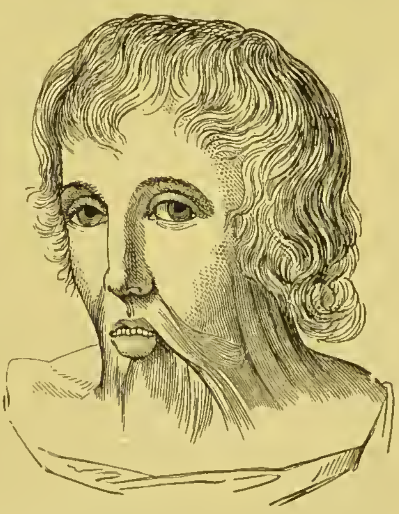


Fig. 1.—Prominent and contracted cicatrices of the neck consequent on a burn (Follin).

In the parenchyma of an organ the contracting scar tissue, whether formed as the result of injury or of long-continued inflammation, causes pressure on the proper cells of the part, leading to their atrophy and absorption; and hence the cells peculiar to the organ, and upon the integrity of which its function depends, are replaced by scar tissue (Inflammation, chap. 2, vol. i.). At first firm, tough, and

perhaps adherent to subjacent parts, a scar becomes with advancing age more loose in texture, more supple, and freely movable.

Union by first intention is the simplest and most speedy process of repair, and in the majority of cases is unattended by pain or constitutional disturbance. The surgeon always aims at attaining this method of union when practicable, but certain conditions are essential. The seat of the injury must be free from all morbid action, and the patient's health must be good, or at least not undermined by any serious disorder. Perfect cleanliness and asepticism

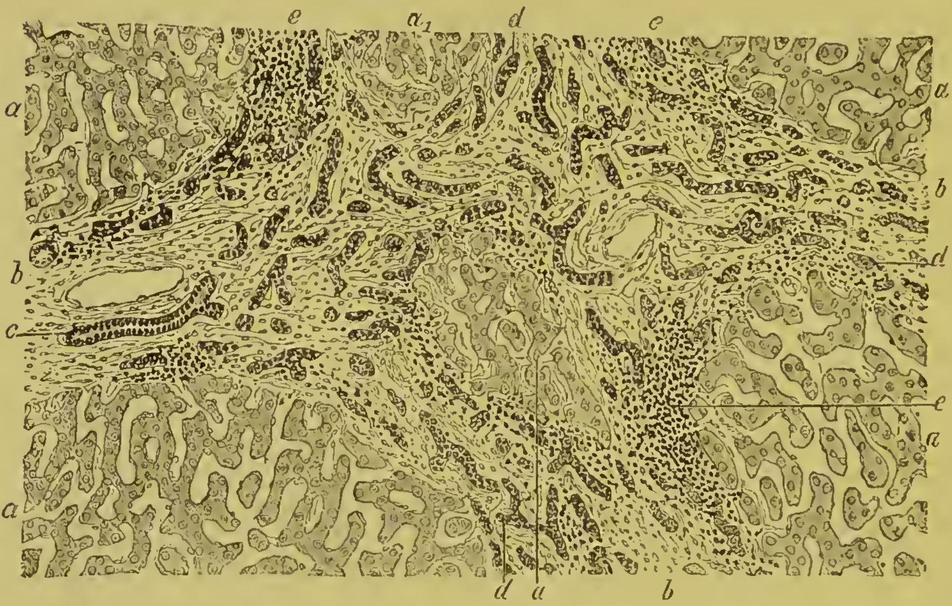


FIG. 2.—Formation of scar tissue and new bile ducts in chronic hepatitis (Ziegler). *a*, a_1, hepatic lobules; *b*, new scar tissue; *c*, old bile ducts; *d*, newly-formed bile ducts; *e*, round-celled infiltration.

must be observed, all foreign bodies, blood-clot, and other sources of irritation being removed and guarded against. The edges of the wound must be accurately approximated with sutures, and perfect physiological rest maintained.

The degree of inflammation attending union by first intention is very slight, reaching its maximum in about twenty-four hours, causing, perhaps, slight redness, swelling, and tenderness along the edges of the wound, but quickly subsiding. The divided vessels are occluded by clot, collateral ones dilate, and lymph and cellular exudate are poured into the margins of the wound, temporarily uniting them—the serum being in part absorbed, in part draining away between the sutures, or forming a crust along the line of incision.

As soon as inflammation has subsided, the further changes already described as being concerned in the formation of the permanent cicatrix occur. The plastic exudate is vascularised by anastomosing loops of new vessels; the fixed cells of the part multiply and replace the leucocytes upon which they live; abundant intercellular substance makes its appearance, fibrillation occurs, and young scar tissue results.

In operation cases, when union by first intention is aimed at, the dressings, unless circumstances indicate otherwise (see p. 11), should be left undisturbed until the end of a week, when the wound will be found quite healed, and the sutures may be removed. Slight wounds may be dressed, and the sutures dispensed with in five days; more serious ones, *e.g.* amputation of the breast, usually require as long as ten days before the last sutures are removed.

Union by second intention or granulation.—If the conditions essential for union by first intention are not fulfilled, repair takes place by granulation, but the process is in its minute details the same.

Hæmorrhage being arrested by blocking of the vessels, inflammatory exudate occurs into the superficial parts of the wound and on to its surface, giving it a glazed appearance. The serum drains away, or if from any cause this is prevented, accumulates in the recesses of the wound and is partly absorbed by the lymphatics. Covering the surface of the wound is a layer of lymph and leucocytes precisely similar in all respects to that forming the temporary bond of union in healing by first intention. New vessels are developed and granulation cells, born of the fixed connective-tissue cells, and acting as phagocytes, gradually replace the leucocytes and form granulation-tissue. The granulation cells find in the escaped leucocytes the pabulum necessary for their maintenance and continued growth, which is further provided for by the development of new vessels. Provided that all sources of irritation are kept from the wound the process of granulation is unaccompanied by suppuration, the discharge, slight in amount after the first day or two, being serous only. If, however, from accidental contamination of the wound, deficient vital power of the tissues, or any other cause, the inflammatory reaction be excessive, then the more superficial leucocytes, being furthest removed from the plasma cells and blood-vessels, perish, and together with exuded serum go to form pus. The presence of pus therefore in a granulating wound shows that there is some deleterious agency at work producing inflammation in excess of that needed. Granulation tissue, like any other, is

capable of continued growth, and thus new tissue is formed until the surface is reached, when the granulating area becomes covered by epithelium cells derived from those at the margin of the skin. Epithelium cells are always derived from epithelium, and never from the plasma cells. As the epithelium grows in from the margin three zones can be distinguished by their colour; the innermost is red, the middle blue, and the outer zone white, the difference in colour being due to the thickness of the epithelial layer. The opaque white of the outer zone is partly due to maceration of the superficial cells by the moisture used in dressing the wound (see chap. iv. vol. i.).

Union of two granulating surfaces.—In the great majority of cases granulating wounds heal from the bottom, but it occasionally happens that two granulating surfaces will unite (as in hare-lip when primary union fails), provided they can be brought into accurate apposition without retention of the discharges, and that the granulations are perfectly healthy.

Union under a scab.—Quite superficial wounds, such as abrasions, heal under a scab formed of coagulated blood and dried serum. A scab effectually keeps the air from the wound, which heals under it in the manner already described. A good scab is quite dry, hard, brown in colour, slightly depressed, and gets somewhat smaller as the wound heals. Scabs often form on unhealthy and dirty wounds and pus collects under them; that such is occurring may be inferred when the scab is heaped up, and "rocks" on the underlying sore when the finger is placed upon it and is moved from side to side. In such cases the scab should be removed and its re-formation prevented by frequent moist antiseptic dressings.

DEFECTS IN THE HEALING PROCESS—DISEASES OF SCARS

In some cases, especially in the aged and infirm, and in those who are the subjects of some disease impairing the general health, the healing of a wound takes place very slowly and imperfectly. The granulating surface is often exuberant, the individual granulations are œdematous, pale, flabby, and easily break down if subjected to the most trivial irritation. Contraction and solidification of the scar tissue is imperfect; the epithelial covering is thin and ill-developed, and even when the wound is completely covered it shows a tendency to break down and reopen, often after a long period. This condition is frequently dependent upon local venous congestion or some other circulatory disturbance, whereby the due

supply of nourishment to the developing tissue is not forthcoming; thus it is often seen in ulcers of the leg associated with varicose veins. Mild, stimulating, and astringent lotions with perfect rest and careful bandaging will usually produce a change for the better. Any constitutional disease, such as syphilis, which may be present, must receive appropriate treatment, and the general health of the patient be improved by dietetic and sanitary measures. For further information of this subject the reader is referred to the chapter on Ulceration, p. 56, vol. i.

Inflammation and sloughing may occur in a granulating wound as the result of some septic or infective process. Repair is not merely brought to a standstill, but the granulations which may have already formed retrograde and slough, the surrounding tissues become angry, red, swollen, and painful, and constitutional symptoms of varying intensity make their appearance. The condition of the wound is due to the direct irritating effects of the septic or infective material in contact with it, and to the general impairment of health which its absorption into the system entails. Locally, treatment must be directed to the establishment of free drainage, the prevention of putrefaction, together with elevation of the part, and the employment of antiseptic fomentations or irrigation. The general treatment must be mainly stimulating; the bowels should be opened but strong purgation avoided, and nourishing food with stimulants administered; quinine and opium are especially useful.

Ulceration of a scar may occur as the result of constitutional disease, *e.g.* syphilis, or from local irritation. If the base of a scar is adherent to deep and dense structures, such as the end of the bone in an amputation, ulceration not infrequently results from pressure. Chronic venous congestion is a fertile cause of ulceration in scar tissue; this is familiar to all who have had to deal much with chronic ulcers of the leg, which even after apparently sound healing break down again under the slightest provocation.

Epithelioma may occur in a scar at any period after its formation, and especially if from any cause there has been long-continued irritation. Scars of burns seem more likely to become epitheliomatous than do those of other wounds. Epithelioma attacking a scar usually grows slowly, possibly because the scar tissue itself is dense and of low vitality.

Scar keloid or Alibert's keloid is a definite new growth of fibrous tissue occurring in the seat of any scar, no matter what its size or position may be; it seems, however, more often to occur in the scar of a burn. Addison's keloid and morphœa are due to

fibroid changes in the cutis not associated with a previous cicatrix. Scar keloids may be very numerous, as in the cicatrices after small-pox. Age and sex appear to have little or no influence in its causation, but black races are peculiarly susceptible. The new tissue is composed of delicate bundles of fibrils with interspersed cells; it begins round the blood-vessels and spreads beyond the seat of the original scar, and is thus distinguished from mere hypertrophy of the scar. The bands of fibrous tissue are arranged parallel to the long axis of the growth, whereas those forming a simple scar cross in every possible direction.

The tumour is dense, hard, and fibrous, raised above the surface with a rounded edge and claw-like processes extending into the surrounding skin. It is usually of a bright pink colour. Pain is generally absent, but a pricking or tingling sensation is common.

Keloid usually progresses slowly for some time, and then remains stationary; in some cases, especially in young patients, it atrophies and disappears.

Treatment is of little use. Excision should not be performed as the growth reappears. Elastic pressure may be tried, and is highly spoken of. If there is much pain or tingling, aconite, morphia, or cocaine may be painted over the growth. Quinine is recommended internally.

CHAPTER III

Gun-shot Injuries

Modes of infliction.—Most gun-shot injuries are caused by rifle and revolver bullets or fragments of burst shells. In civil life similar injuries are usually caused by revolver bullets, or shot from a fowling-piece; more rarely by explosive bombs, fragments of burst boilers, or pieces of rock in blasting operations.

A gun-shot injury is said to be **direct** when it is inflicted by the body (*e.g.* a bullet), to which the propulsive force was primarily applied. **Indirect** injury is caused by substances set in motion by the impact of the primary destructive agent; in warfare such indirect missiles are usually due to the impact of shells or chilled shot against masonry, wood, ironwork, etc., fragments of which are scattered with great force in all directions. The extent of the wound may be increased by foreign bodies, such as portions of clothing, splinters of bone and the like, which have been detached and carried into the tissues or scattered among them by the primary missile.

Nature of the projectile.—The character and severity of a gun-shot wound vary according to the nature, weight, size, hardness, solidity, and shape of the missile, and its rate of velocity at the time of impact.

Shape and velocity of the missile.—Fragments of shell and all indirect missiles, being usually of indefinite shape and size, produce wounds of all grades of severity accompanied by much contusion and laceration of the tissues. Heavy objects may completely smash the part struck, carry away limbs, and cause instant death; or may produce very severe contusion of the soft parts with comminution of the bones if the rate of velocity is low.

The modern rifle bullet is cylindro-conoidal, the old spherical

form being only used for loading shells. Spherical bullets rotate on an axis at right angles to the line of flight, have a low initial velocity which quickly diminishes, and hence are easily deflected from their course by contact with any resistant structure, such as a bone or tendon; they are consequently more likely to lodge in the body than are conical bullets. The injury caused by a spherical ball covers a larger local area, but is not so severe as that caused by a conical bullet.

Conical bullets rotate on an axis incident with the line of flight and act like a wedge; the high initial velocity is maintained, and hence these projectiles are not readily deflected from their course, but traverse the body in a direct line, cut through or push aside tendons, and cause much fissuring of bones.

If the velocity of the ball is increased its destructive power is augmented by the square of such increase. Owing to the slight loss of momentum, lodgment of a conical bullet in the body is rare, and the local area of damage is smaller but more severe than that caused by the spherical ball. The wound caused by a conical bullet is more clean cut, and heals more quickly, and with less tendency to suppuration than does that caused by a spherical ball. The damage inflicted by spent shot is proportional to the size and weight of the projectile, and to the angle of impact. In olden times, when spherical cannon-balls were used, very severe injuries were sometimes caused by injudicious attempts to stop the progress of rolling spent shot, the weight of which was great.

The size, weight, solidity, and hardness of bullets materially influence their destructive power. The modern Lee-Metford bullet (Fig. 3) has a diameter of 0.311 inch, and only weighs 215 grs., *i.e.* less than half the weight of the Snider or Martini-Henry (Fig. 4). It is very hard, and is composed of lead (98 per cent), and antimony (2 per cent), with a coating of copper (80 per cent), and nickel (20 per cent); hence its penetrating power is very great, but — owing to its lightness — the "stopping" power is small. The density prevents the ball splintering. The propulsive power is about 32 grains of cordite.

FIG. 3.—The Lee-Metford bullet.

FIG. 4.—The Martini-Henry bullet.

Soft leaden bullets, especially if travelling at a low rate of

velocity, may become embedded in the bones or soft tissues, or may flatten out or split into numerous fragments on striking a bone (Fig. 7, p. 38).

The heavier the projectile the greater its stunning effect and "stopping" power; in this respect the Lee-Metford bullet is much inferior to the Martini-Henry or Snider.

The nature of the injury.—All gun-shot injuries are contused and lacerated, and as the missile usually penetrates the tissues they are also punctured. The degree of bruising and laceration depends chiefly on the weight, hardness, and rate of velocity of the missile.

A ball travelling at a high rate of velocity cuts its way cleanly through the part in the direction of its line of flight, the aperture of exit corresponding with that of entry provided the patient be placed in the position he was in when struck. The apertures of entry and exit made by the modern conical bullet are slit-like, the edges being in contact, and are sometimes so similar in appearance, that they cannot be distinguished. In the case of spherical or spent conical bullets, the aperture of entry is circular or slit-like, and rather smaller than the missile; while that of exit is larger, much more ragged and torn, with everted edges, and is not often in a line with that of entry, the bullet having been deflected from its path. The differences in appearance of the apertures of entry and exit are dependent upon want of support in the latter situation, loss of momentum of the missile, and consequent diffusion of the force, and in some cases upon its increased size through splinters of bone, fragments of clothing, etc., carried on by the ball. Sometimes there are two or more apertures of exit, due either to the breaking up of the projectile or to the detachment and forcible extrusion of splinters of bone.

FIG. 5.—A bullet wound of the lower end of the tibia, showing the small aperture of entry (Follin).

FIG. 6.—The posterior view of Fig. 5, showing the greater damage inflicted on the bone at the aperture of exit (Follin).

The nature of the wound made by a charge of shot from a fowling-piece (Fig. 7, p. 38) depends upon the range at which it is discharged. At short range the aperture of entry is circular, and more or less ragged, the skin and tissues are charred and discoloured by the lodgment of powder-grains, and pieces of wad may lie within it or be carried into the deeper tissues. On impact, the charge of

shot loses momentum and the pellets scatter; hence there are many apertures of exit, giving the skin a sieve-like appearance. If

FIG. 7.—Shot from a fowling-piece embedded round the ankle. The uppermost pellet has splintered against the crest of the tibia; and others have "pancaked" against the inner surface of the os calcis (Skiagram by H. Montague).

fired at a long range the shot may merely bruise the skin without penetration, or else will remain embedded at a depth from the surface varying with the momentum.

Spent bullets may similarly cause bruising, or may remain

lodged; sometimes—especially if striking obliquely—they perforate the skin and pass beneath it for some distance, either lodging at the end of the track or passing out again (*seton wound*), but are prevented from penetrating deeply, owing to the resistance of the deep fascia.

The damage done to the deeper structures by a bullet varies within the widest limits. The hole in the deep fascia is slit-like, and thus offers a decided impediment to the escape of discharges which may subsequently form. **Muscles** may be simply punctured or extensively smashed and pulped; tendons may be cut through or pushed aside, or may deflect or stop a nearly spent ball. **Nerve-trunks** and **vessels** may be cut across or bruised, though they often escape owing to their lying in naturally protected situations. A vessel which has been contused may subsequently be the seat of secondary bleeding or traumatic aneurism. If a large vein about the neck or axilla be wounded, air may be sucked into the heart with fatal results (p. 63).

When a bullet strikes a **bone,** the damage inflicted varies with the shape, hardness, and rate of velocity of the missile. Thus the bone may be perforated, splintered, comminuted, or severely fissured by a conical bullet at a high rate of speed, and the splinters may be completely torn away from their periosteal connections and driven among the muscles or through the skin. When a bone is fissured the neighbouring joint is not infrequently involved by extension into it. The periosteum over fissures is often intact, so that there is no displacement of fragments, and the actual extent of the damage has to be inferred rather from the known shape of the missile and the circumstances attending the injury than from physical examination. Spent shot may cause a mere contusion, or the ball may fracture the dense outer bony wall and remain embedded in the cancellous tissue. If a bullet strikes a bone obliquely it may cut a deep groove in it (*gutter fracture*), or may glance aside. The old spherical balls caused extensive damage to a bone at the point struck, and often remained embedded; the degree of fissuring was less, but comminution greater than is the case with the modern conical projectiles. Soft leaden bullets may splinter or flatten out on impact with a bone.

Joints may be injured directly, but more usually are implicated by smashing of the articular ends or fissuring of the bones.

It may be difficult—especially in the case of the deeply-seated hip—to ascertain whether a joint has been damaged or not, as the escape of synovial fluid externally is unusual. In arriving at a

conclusion the surgeon must consider the probable direction taken by the ball, the damage inflicted on the bones, and the presence of swelling of the articulation; a probe should not be used, examination with the finger being alone justifiable, since a hard metal instrument may easily be pushed through the intact capsule, and thus inflict the very injury which, it is hoped, has not been incurred.

The **viscera** may sustain damage similar to that inflicted on muscles, being either cleanly perforated or smashed and pulped. Heavy projectiles—such as pieces of burst shell—moving slowly, or striking the body obliquely, may by their weight cause the most extensive damage, contusing and lacerating the soft parts, fracturing bones, and crushing the viscera; and all this even without breaking the elastic and resilient skin. Large and heavy projectiles may completely tear away limbs or portions of the body.

Symptoms.—**Shock** is proportional to the severity of the injury, the importance of the parts damaged, and the amount of blood lost. It is also felt in a much deeper degree by some races and individuals than by others. If shock be very profound and long-continued it points to some serious damage of internal organs. In actual warfare, wounds are usually received at a time of mental excitement so intense that men frequently undergo the most severe and even ultimately fatal injuries without being aware of the fact. This condition of mind delays the appearance of shock; which, when it does come on, is more profound than it would have been had the injury been sustained in cooler moments, since excitement itself leaves the nervous system in a state of exhaustion. The symptoms and treatment of shock are described at p. 20.

Thirst is a prominent and distressing symptom, due partly to the loss of blood, and partly to the excitement and heat of conflict.

Pain at the moment of being struck may be quite unnoticed, since the patient is often in a state of great excitement, and the infliction of the injury occupies a small fraction of a second only. The pain is described as being like that of a smart blow from a whip, and may at first be succeeded by a condition of local numbness and blueness about the skin. Subsequently, when all excitement has subsided, the pain may be very intense and of a burning character, especially if a nerve has been injured or the wound is irritated by the presence of a foreign body. As with shock, so with pain, some suffer much more severely than do others, and this even from slighter wounds.

Hæmorrhage.—If large vessels are cut across, the patient

usually dies before any assistance can reach him. In cases coming under the care of the surgeon, the amount of primary bleeding is usually slight, as small vessels only are wounded; being contused and lacerated they have contracted and retracted, and thus spontaneous arrest has been secured. Moreover, if the wound is made by a ball travelling quickly the aperture is small, and the blood, accumulating and coagulating along its track, offers a bar to any further escape. When an entire limb is carried away by a shell, the main vessels are pulled from their beds, and may be seen pulsating freely, but not bleeding, as natural torsion has occurred (see p. 18).

Soldiers who are instantaneously killed, especially by wounds of the brain, immediately pass into extreme rigor mortis, so that when dead they may appear as if still living, and attempting to complete some act on which they were engaged when struck.

Prognosis and secondary dangers.—The prognosis naturally varies with the severity and seat of the injury, and materially depends upon the hygienic surroundings of the patient, the facilities for the carrying out of antiseptic methods, and lastly, upon whether the projectile or foreign matters are embedded in the wound or not.

Since the application of antiseptics to military surgery, bullet wounds of all parts, including extensive fractures and injuries of large joints, have proved much less fatal. Suppuration is by no means constant, and many even serious wounds may heal by first intention, provided strict asepsis is observed *from the very first.* The conical bullet, moreover, inflicts a more clean-cut wound, and one therefore much less likely to lead to inflammation and suppuration with their attendant dangers.

Suppuration is, however, very common, especially if the parts have been much contused and if the ball or some foreign material remains embedded in the tissues. Unless asepsis is maintained, purulent and serous discharge may undergo putrefactive decomposition, and, being perhaps pent up in the recesses of the wound, may lead to serious local mischief attended by sloughing.

Secondary hæmorrhage may result from suppuration and sloughing, or from inflammatory softening of a contused artery. Arterial injury may also lead to gangrene.

Diffuse cellulitis, erysipelas, septic infection, and hospital gangrene may all occur; but the two last have almost disappeared since the use of antiseptics.

Loose splinters of bone may necrose or excite long-continued inflammation and suppuration, and should decomposition occur,

the patient may be carried off by hectic or some infective process, unless the source of irritation be removed by amputation or some less drastic measure.

Injury of a nerve trunk may be followed by the changes mentioned on p. 131.

General principles of treatment.—Temporary means must be adopted for the arrest of hæmorrhage, the maintenance of rest for fractured bones, and other conditions which may demand immediate attention pending such time as the injury can receive full attention. Shock must be combated at once or it may prove fatal.

As soon as the patient is placed under the surgeon's care, the wound must be thoroughly explored and cleansed, under anæsthesia if necessary. The examination should be carried out as far as may be with the patient in the position in which he was when struck. The exploration of the wound should be made by the finger, a probe never being used unless the wound is very long, and if necessary the orifice must be enlarged. The course taken by the ball will give the surgeon some indication of the probable nature

FIG. 8.—Nélaton's bullet-probe.

and degree of the damage which the parts have sustained. All foreign bodies and detached splinters of bone must be carefully removed. If the bullet be impacted its situation should be ascertained by the finger, but if this cannot reach it, Nélaton's bullet-probe coated with biscuit-china may prove useful (Fig. 8). When a bullet can be removed without much difficulty this should always be done; but more harm than good may result from over-zealous attempts to dislodge a firmly impacted ball, or to seek one the position of which is more than doubtful. The situation of impacted bullets may now be easily ascertained by the Röntgen rays (Fig. 7, p. 38). A ball that is left unextracted may become firmly encapsuled and do no harm; or it may betray its seat at a later date by exciting suppuration in its neighbourhood.

Bullets may be dislodged with the finger, but if firmly embedded in a bone, bullet-forceps (Fig. 9), the elevator, or a screw extractor (Fig. 10) are necessary. A ball should always be extracted by the shortest route that the anatomy of the parts allows. When all foreign bodies have been removed, the vessels ligatured, and the nerves and tendons sutured, the wound must be thoroughly cleaned with 1 : 20 carbolic, or 1 : 1000 mercury solution. The

latter is more applicable to military surgery, as it is easy to transport. Free drainage must be provided, and counter-openings made if necessary. The question of sutures must be decided on the merits of the case (see p. 13).

In all cases a dry antiseptic dressing should be applied, and should not be changed unless the condition of the patient or the escape of discharges render this necessary (p. 11).

Fractures must be treated according to their position and

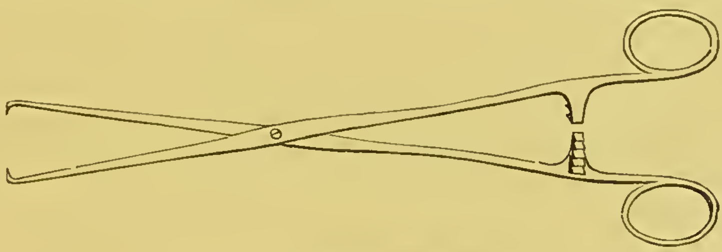


FIG. 9.—Luer's bullet-forceps.

nature. Plaster of Paris is the most convenient form of fixing apparatus, and a window may be cut in the casing over the situation of the surface wound. If a joint is wounded, complete cure may be secured without suppuration by the use of antiseptic dressings; in bad cases excision or amputation may be required.

The frequency of primary **amputation** for gun-shot injury is much less now than it was before the introduction of antiseptics,

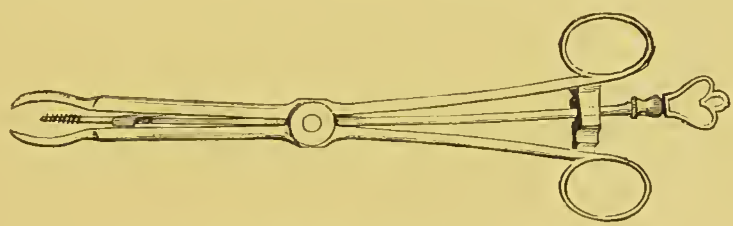


FIG. 10.—Bullet-forceps and screw extractor.

their use enabling the surgeon to save limbs which formerly would have been condemned. Primary amputation is called for if a limb is completely shattered, or if there is much laceration with wound of the main artery or large nerve trunks. Extensive fracture of the end of a bone with implication of the joint usually necessitates amputation, but much depends on the merits of each case.

Injuries of similar extent in the upper and lower limbs must not be treated with the same severity as regards primary amputation,

for the upper extremity is much more readily saved than is the lower. Severe gun-shot injuries of the thigh are especially dangerous, but amputation apparently offers the best chance of success.

If it is decided to perform primary amputation the operation should be done without delay, unless shock be severe; in the latter case recovery should be encouraged and the operation performed as soon as the patient's condition is sufficiently favourable. Secondary amputation may be necessitated by uncontrollable secondary hæmorrhage, by prolonged suppuration, by necrosis of bone, or by the supervention of hectic threatening the life of the patient. The operation should, if possible, be postponed until the state of the wound has been improved and the patient's general health is fairly good.

The general treatment of those injured by gun-shot consists in supplying them with plenty of good food, with stimulants if necessary, and placing them under the best hygienic conditions.

Morphia and anodynes are called for if there is much pain. The bowels must be kept acting, and the action of the kidneys and skin encouraged.

During convalescence, iron, quinine, and general tonics should be administered, especially if the patient is anæmic from loss of blood.

CHAPTER IV

The Effects of Heat, Corrosives, Caustics, and Cold

BURNS AND SCALDS

Contact with dry heat produces a burn; with steam, or moist heat, a scald. The severity of the local injury is proportional to the degree of heat and the length of time it operates. Thick and oily fluids which retain heat for a long time and stick to surfaces with which they are brought in contact cause the severest scalds. As a rule scalds do not affect the tissues so deeply as burns, but they implicate a larger surface area.

Dupuytren classified burns into six degrees according to the depth, but clinically this is unnecessary. Following this classification we have:—(1) Simple hyperæmia without destruction of tissue; (2) hyperæmia with serous exudation beneath the superficial epithelium; (3) destruction of the superficial parts of the skin, including the tips of the papillæ and openings of the glands; (4) destruction of the entire skin with involvement of the subcutaneous tissue; (5) involvement of the deep fascia and superficial muscles; (6) charring of the entire thickness of the part.

For practical purposes burns are conveniently divided into three classes:—

(1) Those causing hyperæmia of the skin (Dupuytren's first and second degrees).

(2) Those implicating the true skin, but not extending beyond the deep fascia (third and fourth degrees).

(3) Those extending to the muscles and deeper structures (fifth and sixth degrees).

(1) **Hyperæmia—Scorching.**—Burns and scalds of this nature are never serious unless they implicate a large surface area. There

is redness, tenderness, and smarting, and in the severer forms blisters occur owing to the accumulation of serum beneath the superficial layers of the epithelium. Recovery is usually complete in from seven to ten days. The epithelium desquamates.

(2) **Implication of the true skin.**—This is the form of injury usually coming under the surgeon's notice. In the milder cases the superficial part of the skin is destroyed. Healing is rapid, the epithelium being derived partly from the margin of the wound and partly from the undestroyed glands. Contraction of the new tissue does not occur. In more serious burns, where the entire skin has been destroyed and the subcutaneous tissue is affected, healing is much more prolonged since, the glands being destroyed, epithelium can only be derived from the margin of the skin. The contraction of the new scar tissue is great and may occasion serious and lasting deformity. As a general rule, burns of this class vary in depth at different parts, and it is often impossible until the separation of the sloughs to determine to what depth the skin has been destroyed. Burns which only destroy the superficial part of the skin may, as the result of consecutive inflammation and sloughing, eventually extend more deeply.

The burnt surface is covered with a brown or black, rather tough eschar, which is ultimately separated by a process of destructive inflammation. The surrounding parts are red and congested, and may be shot with capillary hæmorrhages. This hyperæmic zone is not present in burns caused after death.

(3) **Destruction of muscles and deeper structures.**—Burns of this degree are not commonly met with in practice, since their occurrence implies an inability on the part of the patient to escape from the fire, such inability usually leading to a fatal result.

The general effects of burns.—The constitutional effects of burns vary within wide limits, which are dependent upon the age and general health of the patient, and the situation, depth, and surface extent of the injury (see Prognosis). The constitutional disturbances are divisible into three stages:—

The stage of shock and visceral congestion extends over the first two days. Shock may be of the usual type, but is sometimes accompanied by excitement and convulsions ending in coma and death. Great thirst, persistent vomiting, and shivering are not uncommon. Pain varies in degree, being most severe in burns implicating the superficial parts of the true skin. It may, however, be absent on account of severe shock; in such cases the prognosis is very grave, even though the patient be quite conscious. Visceral

congestion, especially of the brain and its membranes, less frequently of the lungs and intestinal tract, may occur during this stage. Delirium and coma, rapidly terminating in death, point to congestion of the brain and its membranes. Albuminuria may be present from renal congestion, and as a rule the amount of albumen is proportional to the height of the temperature, which begins to rise as soon as shock passes off.

The stage of reaction and inflammation extends from the second to the fourteenth day, the duration depending on the severity of the burn. It is characterised by inflammation of the damaged parts and, in some cases, of the viscera, especially the lungs and intestinal tract. The temperature rises, partly from the inflammation, partly from septic absorption, and in extensive burns, perhaps from the retention of nitrogenous waste products which should have been excreted by the destroyed skin. The pulse becomes fuller, and thirst, anorexia, and diarrhœa are present. If the fever, in spite of antiseptic precautions, remains persistently high, some visceral lesion may be suspected, and its characteristic signs should be looked for. During the second week acute perforating ulcer of the duodenum may occur.

The stage of suppuration and exhaustion.—During this stage the separation of the eschars and the growth of granulations proceeds. The patient is exposed to all the dangers of septic or infective poisoning, and hectic fever may be present from chronic septic intoxication. Of internal complications pneumonia and duodenal ulcer are the most frequent. Death may occur from exhaustion, as in other chronic suppurations.

Complications of burns.—**Visceral congestion and inflammation** is one of the most common and serious complications of severe burns, especially at the two extremes of life. The brain and its membranes, the lungs, kidneys, and intestinal tract are most usually affected, but no organ is immune. The situation of a burn influences to some extent the seat of the complication; thus in the case of the head and neck, meningitis, encephalitis, diffuse cellulitis, and œdema laryngis may occur; while in the case of the trunk the lungs, pleura, peritoneum, and intestinal tract are more likely to suffer.

Erysipelas is not uncommon, and **septic intoxication** is very prone to occur unless scrupulous cleanliness be observed.

Hæmorrhage may set in during the separation of the eschars, but it is usually slight, as the larger vessels run beneath the deep fascia, and thus in most cases escape injury.

Duodenal ulcer occurs in a very small proportion of cases. Similar ulcers may be, though rarely are, present in the stomach or some other part of the intestine. The ulcer is not usually found in cases dying before the tenth day, and is more common in children than adults. It is situated close to the pylorus, often anteriorly; it is circular in outline, clean-cut, about the size of a shilling, and tends to rapid perforation of the bowel. Profuse hæmorrhage is common. The signs of duodenal ulcer are sometimes so masked that the condition is only found *post-mortem.* Epigastric pain and tenderness, gastro-intestinal irritation, diarrhœa, and vomiting, with blood in the voided matters, are very suggestive symptoms, but may be absent. In many cases sudden collapse from perforation or severe bleeding is the first and only sign of the occurrence of ulceration. Duodenal ulcer is usually fatal from one of these causes, but recovery may take place.

Pathology.—The pathology of the complications of burns has excited much discussion and still remains *sub judice.* The congestion and inflammation of the viscera has been attributed by Ponfick to capillary embolism, due to breaking up of the red cells and to the hæmoglobinuria, which occurs in severe burns. Similar blood changes, however, are met with in cases of septic absorption, which, as has already been pointed out, is of common occurrence in these injuries. It has, moreover, been shown by Hoppe-Seyler that, although blood changes are undoubtedly present, they are not of sufficient gravity to induce such serious and often widespread inflammation. According to others, the destruction of a large area of skin diminishes cutaneous respiration, in consequence of which nitrogenous waste products are retained in the blood, and act as chemical irritants to the viscera; yet visceral inflammation is by no means limited to cases where a large tract of skin has been destroyed, but may occur in burns covering a small area, and in which the cutaneous respiration cannot be appreciably checked. In some cases perhaps the congestion is dependent upon reflex irritation of the vasomotor centres of the spinal cord. Lastly, the influence of septic absorption must be considered. A plentiful supply of septic material is present in all cases, and from what we know of the effects of absorption of septic matter, we should expect that secondary inflammations would ensue should this occur. Dr. W. Hunter has adduced evidence to show that the duodenitis and consecutive ulceration are due to poisons absorbed from the burnt surface and excreted by the bile. Duodenal ulcer has long been attributed to gastric digestion of an area which is the seat of

hæmorrhagic infarction due to embolism; but in view of Dr. Hunter's observations and other considerations the correctness of this theory is very doubtful.

Prognosis.—The gravity of a burn depends in great measure upon its extent, depth, and situation, and the age of the patient. Death occurs most frequently during the first stage, least so during the third. Even slight burns may cause death if they affect a large surface; it is usually said that a burn of the first degree proves fatal if it involves one-third of the body surface. Other things being equal, the deeper the burn the greater the danger; but the extent of surface damaged is of far greater importance. Burns of the head, neck, and trunk are, owing to the frequent occurrence of complications, more serious than similar injuries of the extremities. The young and old are bad subjects, the former being especially prone to visceral inflammation; even a small burn in a young child should always be regarded as a serious injury. The subjects of renal disease, chronic alcoholism, or any chronic visceral mischief are necessarily bad patients. During the first stage death may occur from shock or cerebral congestion; in the second pneumonia, duodenal ulcer, and gastro-intestinal congestion are the chief dangers; while exhaustion and septic and infective processes are to be dreaded in the third.

Treatment.—The treatment of burns is constitutional and local, and necessarily varies with the severity of the injury.

Constitutional.—During the first stage every effort must be made to combat shock and encourage reaction. The patient should be wrapped in blankets, surrounded with hot bottles, and should have a full dose of opium, especially if there is much pain. Immersion in a warm bath (95°-100° F.) is an excellent method of relieving shock and pain; the patient may be kept in it for some hours. An enema of hot brandy and water is often beneficial. During the reaction period warm beef-tea and milk, with small quantities of stimulants, may be given; should there be much thirst, as is so often the case, small pieces of ice may be sucked, and milk mixed with lime water may be freely taken if vomiting is present. During the second and third stages the surgeon's efforts should be directed to maintaining the patient's strength and to the avoidance of depressing remedies. Ammonia and alcoholic stimulants, bark and quinine, with plenty of easily digestible nourishing food, are the chief means of attaining this end. When suppuration is established and the sloughs are separating, fish, roast-meat, port wine, and stout should be given if the state of the digestive organs will permit. Under all

circumstances the dietary and amount of stimulants must be judiciously regulated, sufficient but not too much being given; for it is more harmful than beneficial to press food on a patient which he is unable to digest.

With regard to complications, these must be treated as they arise and according to their nature, due regard being paid to the depressed state of the patient by reason of the injury he has sustained.

Local.—The mildest degrees of burns need little or no local treatment except protection from the air. The scorched surface should be freely powdered with flour, boric acid, starch, or bicarbonate

FIG. 11.—Cicatrix resulting from a scald. The degree of extension permitted at the elbow joint is shown (Fergusson).

of soda, and then swathed in cotton wadding. If blebs are present they should be pricked, but the epithelium should on no account be removed, since it protects the highly sensitive papillæ.

Cooling lotions are often more soothing and agreeable to the patient than the method above given, but they can only be used in burns of limited extent.

In the more severe cases, where there is destruction of part or all of the thickness of the skin, local treatment is very important. The clothes should be removed with the greatest care, so that no burnt tissue may be torn away; if the clothes adhere, the patient must be placed in a warm bath (as much clothing as possible having been first cut away), and the adherent parts, when thoroughly soaked, should be gently removed. Many methods of dressing burns have been and are still employed; whatever dressing is chosen should be

changed as seldom as possible, not only on account of the pain it causes, but because exposure to the air does harm. If a burn covers a large area it should not all be uncovered at once during the dressing. Among the substances used may be specially mentioned boric acid ointment, iodo-vaseline, carron oil, eucalyptus oil, carbolic oil, and carbolised ointments; all are good, and all have their advocates. The ointment should be spread on fine butter-cloth, and should cover the whole surface. When the dressing is changed the discharges should be washed away with a gentle stream of weak boric acid solution, iodine solution, or carbolic acid, 1 : 80, but strong antiseptic lotions should be avoided. A saturated solution of picric acid may be applied as a wet dressing, and may remain untouched for two or three days; this sometimes gives excellent results; it must only be used for superficial burns, and not in these if they be extensive, for toxic symptoms may be induced; the cuticle should, where it is separated, be cut away before the solution is applied. Above all things decomposition must be prevented.

FIG. 12.—The same arm as Fig. 11, four months after treatment by incision and removal of the dense cicatricial bands beneath the skin (Fergusson).

When the eschars begin to separate the dead parts may be cut away, but no forcible attempt must be made to pull them off. As soon as the sloughs have separated the wound is practically a granulating sore, and must be treated like a granulating wound from any other cause. Contraction must be prevented by appropriate mechanical contrivances and elastic pressure over the wound.

Skin grafting is most useful in this respect. Should contraction occur in spite of all efforts to prevent it, operative interference becomes necessary. Burns of the higher degrees causing destruction of muscles and charring of a limb usually require immediate amputation, the patient being allowed to recover from shock before the operation is performed.

SUNBURN

Exposure to the sun's rays causes cutaneous erythema and burning of varying intensity. Fair people with delicate skins are the most easily and severely affected. Sunburn is most intense at high altitudes, especially if the rays are reflected from new snow; those reflected from water are also very powerful. Continued exposure to the sun causes bronzing, and this may or may not be preceded by erythema, depending upon the heat of the sun and other causes. Similar bronzing also occurs in those exposed to strong electric light. That sunburn is not merely the effect of heat is shown by the fact that iron-workers, who are exposed to much greater heat, do not so burn. It has been shown by Bowles that burning is more likely to occur when the violet and ultra-violet rays are very strong, as they are at high altitudes.

In mild cases there is little more than erythema, with some smarting for a few hours, and ultimate desquamation; in more severe ones vesication occurs, accompanied by exudation of serum, with much swelling, heat, and intense smarting pain; the conjunctivæ are swollen and ecchymosed, and there is chemosis.

In the worst forms of sunburn the erythema passes on to true dermatitis of an erysipelatoid nature, and this, if the burning be extensive, may be very serious.

Treatment.—Those who burn readily should adopt preventive measures. An ointment composed of tinct. calendulæ ʒi., ung. cetacei ʒi., lanolin ℥i., should be rubbed over the skin before exposure, and occasionally during it; this should be washed off at night with tepid water, the parts gently dried, and the ointment reapplied. Brown veils or masks are also good preventives.

When once burnt the above ointment affords relief; if, however, the pain is great, lanolin with cocaine or morphia is the best application. Lime water, glycerine and water, or any mild lotion will also give relief, but are more troublesome of application.

BURNS FROM CORROSIVES AND CAUSTICS

Mineral acids and their salts, carbolic acid, caustic alkalies, and phosphorus are the substances most commonly producing severe burns. They act in the same manner as if a hot iron had been applied to the part, killing the skin, and inducing sloughing and more or less intense inflammation. The effects of these substances when swallowed will be considered at p. 294.

Treatment.—The treatment of such cases does not differ from that of burns produced in the ordinary way, but immediate steps should be taken to render the caustic or corrosive fluid harmless. In the case of the mineral acids or their salts, these should be neutralised by covering the part with chalk; water should be avoided, since, when mixed with these acids, it causes a sudden evolution of heat.

Caustic alkalies may be rendered harmless by vinegar or some dilute acid, an innocuous salt being thus formed. Oil applied to the burnt surface will act by forming a soap. Burning by phosphorus is usually severe and deep, since this substance burns until it is consumed.

The Local Effects of Cold

FROST-BITE

The effects of severe cold depend upon a variety of circumstances. Cold is badly borne by the young and old, and by those whose circulation is feeble, or who are in a depressed state of health from chronic disease, long exposure, or bad living—as is amply proved by the surgical history of many campaigns. Cold and wet combined, and cold accompanied by a high wind, which carries off the bodily heat rapidly, are especially harmful.

Those parts which are most exposed, and whose circulation is naturally feeble, are the most liable to frost-bite, viz. the fingers, toes, ears, nose, chin, and the skin over the malar bones.

Frost-bite is very prone to attack any part which is the seat of a wound or abrasion.

Cold induces extreme vasomotor contraction, with slowing or arrest of the circulation, and venous congestion from loss of *vis à tergo*. The tissues may be killed outright by freezing, and become a dead-white colour, and completely anæsthetic. Even after freezing recovery may take place, provided it has not been of long

duration. As soon as the effects of cold begin to pass off reactionary hyperæmia and inflammation set in, and if this be induced too rapidly the inflammation may be so intense and the exudate so plentiful that moist gangrene results. Gangrene arising as the direct result of freezing is of the dry variety; the dead-white colour subsequently turns to black, and the dead portion shrivels and slowly separates, leaving an intractable ulcerated surface, which heals very slowly, since the tissues have suffered severely from the cold.

When recovery occurs from frost-bite, the dead-white colour gradually disappears, giving place to livid redness; there is some swelling from inflammatory exudation, and intense, sometimes agonising, burning pain. Pain is an encouraging symptom, as it proves the part to be still capable of recovery under appropriate treatment.

Treatment.—Those who are exposed to severe cold should counteract its harmful effects by friction and continuous movement. It is a popular belief that spirits taken internally ward off cold, whereas alcohol lowers the bodily temperature, and does much harm; it should therefore be sedulously avoided, except in cases of extreme cardiac depression.

In mild cases of frost-bite, gentle and prolonged friction with snow, and elevation of the part to encourage the venous return, will readily restore vitality. When the frost-bite is more severe great care must be taken not to bring on reaction too quickly, or inflammatory gangrene will result. The patient should on no account be taken near a fire or even into a warm room. The frost-bitten part should be immersed in ice-cold water and gently rubbed, or friction with snow may be employed. Tepid or warm water does more harm than good. When reaction begins, intense burning pain is experienced, the dead-white colour disappears, and the circulation is re-established. This stage being reached, friction may be replaced by wrapping the part in cotton-wool or flannel.

Should gangrene occur, either as the direct result of the freezing or from reactionary inflammation, antiseptic applications should be applied. Sloughs must be left to separate by themselves; any attempt, however slight, to remove them sometimes exciting severe inflammation of the still living but damaged tissues. Amputation should never be undertaken until separation of the dead portion has made some progress. This is very important, since the parts close to the line of separation, and through which the amputation must be made, have themselves been affected by the cold, and require time to recover before any wound is inflicted.

CHILBLAINS

A chilblain is a mild form of frost-bite, occurring generally in young children, especially girls. The fingers, toes, and ears are usually affected. Those of naturally feeble circulation are very prone to suffer severely in cold weather. Repeated chilblains during the spring and summer months should lead the surgeon to suspect Raynaud's disease (see p. 82, vol. i.).

A chilblain consists of a red or livid-blue swollen patch, accompanied by tingling and smarting; in more severe cases vesication occurs from serous exudation beneath the superficial layers of epithelium. The vesicles may rupture and occasion prolonged and troublesome ulceration, or even sloughing of the skin.

Treatment.—Those who suffer from chilblains should be warmly clad, take plenty of exercise, and avoid sudden changes of temperature. Tonics, good food, and cod-liver oil are beneficial.

During the early congestive stage of chilblain, gentle friction with some stimulating liniment will usually effect a cure. The best applications for this purpose are soap liniment with tincture of opium or iodine, or the compound camphor or belladonna liniments; or the part may be painted with tincture of iodine or tincture of benzoin. If vesicles form they should be emptied, but the epithelium should not be removed, as it serves to protect the part beneath. These so-called "broken chilblains" are best treated with resin ointment.

If ulceration or sloughing occurs the wound must be dressed with mild antiseptic lotions. Healing is often tedious.

CHAPTER V

INJURIES OF BLOOD-VESSELS—HÆMORRHAGE

INJURIES OF ARTERIES

ARTERIES are especially protected against injury by their anatomical position, shape, elasticity, and strength. Fōr the most part the main trunks lie deeply embedded among the muscles and on the flexor aspect of the limbs. Being circular they readily slip aside when subjected to violence, and owing to their elasticity they may be compressed without sustaining injury, unless the force be severe and long continued; moreover, the tough and stout outer coat, in addition to the investing sheath, protects the more brittle inner and middle coats, and in the event of their injury often serves to maintain the continuity of the vessel.

Contusion.—An artery may be contused without rupture of any of its coats, in which case no permanent injury is usually sustained. If, however, the contusion has been very severe, some diminution of calibre may result from inflammation of the vessel wall, or inflammation and softening may lead to secondary hæmorrhage. A contused artery may be permanently weakened and aneurismal dilatation be thus induced.

Contusion may, as in the application of a ligature, cause rupture of the middle and internal coats.

Rupture of an artery may be partial or complete.

Partial rupture may result from severe contusion, pressure, or traction. From these causes it sometimes occurs during an attempt to reduce an old dislocation. Ligature may cause partial rupture. The inner coats are torn across, but the continuity of the vessel is maintained by the integrity of the stronger outer coat. The torn coats retract and contract (Fig. 13) and thereby block the vessel

and lead to thrombosis and permanent obliteration in the manner to be afterwards described. Sometimes rupture of the inner coats leads to the formation of a dissecting aneurism, the blood finding its way between the layers of the middle coat. Partial rupture, by weakening the vessel wall, may lead to the formation of a sacculated aneurism. In some cases of partial rupture, the retraction of the torn coats within the outer may be prevented by previous matting of the coats from disease; a similar condition would also be a safeguard against the formation of a dissecting aneurism. When, from the nature of the accident, partial rupture is suspected, its occurrence may be determined by careful examination of the limb. The circulation below the seat of injury will be necessarily impaired, as can be ascertained by comparing the pulsation on the two sides; there is tenderness, and slight swelling can usually be detected if the artery is not too deeply placed. In such cases the limb should be elevated and kept warm by wrapping in cotton wadding, and complete rest maintained for about a fortnight.

FIG. 13.—An artery after the application of a ligature. *a*, the vessel; *b*, the point of ligature showing rupture of the internal and middle coats, which (*c*) have retracted within the outer (Follin).

Complete rupture occurs most usually in lacerated wounds, especially those caused by machinery accidents and gun-shot injuries; it may, however, occur without any external wound, especially if the vessel be diseased.

In machinery accidents, portions of a limb may be completely torn away, the arteries being torn from their sheaths and dragged out from their beds. The middle and inner coats retract within the outer, which is drawn out to a point and twisted on itself so that hæmorrhage is effectually prevented by the occurrence of what is, in fact, natural torsion.

Subcutaneous rupture of an artery gives rise to profuse hæmorrhage, and the formation of a diffused traumatic aneurism (see p. 58). The accident, most usually occurring in the popliteal, is a very serious one, its ultimate effects depending on the size and position of the damaged vessel.

Penetrating wounds of arteries are inflicted with sharp-pointed instruments. If the wound is small it may be blocked by coagulum forming between the vessel wall and its sheath, and to a less extent on the inner surface of the artery; this coagulum prevents any further escape of blood.

Punctured wounds of arteries are always serious injuries and may prove fatal through hæmorrhage. Some of the effused blood will escape externally, but if the wound, as is so often the case, be very small, the blood accumulates in and distends the tissues, giving rise to a diffuse traumatic aneurism.

In the case of a minute puncture the wound may heal without permanent damage, or the cicatrix may gradually yield, and a sacculated aneurism result.

When an artery has been punctured, the wound leading to it should be enlarged, the artery sought for and divided between two ligatures.

Incised wounds.—An artery may be *completely* or *partially* divided. In the latter case the vessel is unable to contract or retract, the wound gapes considerably and profuse hæmorrhage results. The more nearly transverse the incision, the more free will be the hæmorrhage, because the gaping of the wound is greater. In all cases of partial division the vessel should be completely severed and a ligature applied to each end.

DIFFUSE TRAUMATIC ANEURISM

When an artery is wounded, either subcutaneously or by puncture, so that the blood does not escape externally, it is effused into the surrounding soft parts; this constitutes a diffused traumatic aneurism. The extravasation is bounded by the tissues only, its extent depending on the size of the vessel wounded and on the natural elasticity or resistance of the neighbouring structures. There is no sac wall, and hence the term aneurism is incorrect and misleading.

The hæmorrhage continues so long as the tissues are capable of distension under the blood-pressure, but is arrested when the tension is high enough and the blood has partially coagulated. The amount of bleeding may, in the case of large arteries placed among loose structures, *e.g.* the axillary, be in itself a serious danger and may even prove fatal. In no case does spontaneous cure occur, although some of the blood coagulates. If left alone, the swelling gradually increases in size and the skin may inflame and slough in consequence of pressure, the blood then escapes externally and death results unless assistance be at hand. In other cases suppuration occurs, and unless immediate preventive steps be taken the abscess will burst and fatal hæmorrhage ensue.

The pressure exercised by the extravasated blood interferes

with the venous return, and gangrene may result. The popliteal is the most usual seat of this accident.

Signs.—If the hæmorrhage be large in amount the patient may show all the constitutional signs consequent on severe bleeding (see p. 67); short of this there will probably be a feeling of faintness. Locally, the patient experiences a sudden tearing pain at the time of the injury, and if there is a wound leading down to the damaged vessel, blood escapes externally. There is great and rapid swelling, coldness of the limb, and diminution or loss of pulsation in the vessels below. Soon after the accident the swelling, which at first has formed rapidly, increases more slowly in consequence of the resistance offered by the tissues. There may be faint pulsation in the tumour, but usually there is none, or if present at first it quickly disappears as tension increases; a thrill and bruit may or may not be present. Ecchymosis and discoloration of the skin are usually present unless the vessel be very deeply seated. As tension increases, the pain becomes more severe and there is œdema of the parts below the point of rupture in consequence of the interference with the venous return, and gangrene will in all likelihood ensue. If the case be left untreated and the interference with the circulation is insufficient to cause gangrene suppuration is to be feared, and will give rise to the local and constitutional signs of acute abscess.

Treatment.—As spontaneous cure can never be hoped for, prompt treatment is necessary to avert the risks attending rupture, suppuration, or gangrene. The treatment is simply that of primary hæmorrhage, the only difference in the conditions being that instead of the blood escaping externally it is poured into the tissues of the part and confined by them.

As a temporary means, pressure should be applied on the cardiac side while preparations are being made to expose and ligature the vessel. The operation is difficult, and unless efficient means be adopted to restrain further hæmorrhage during its performance is dangerous also.

Operation.—The patient being anæsthetised, a tourniquet is applied to the artery above the seat of rupture. An incision is made over the swelling and the blood-clot turned out. The surgeon now searches for the ruptured vessel; if, as is often the case, there is any difficulty in finding it, the tourniquet may be gradually loosened, when the flow of blood will indicate the seat of rupture. When the artery is found it should be carefully cleaned, care being taken that any accompanying veins are not damaged,

and a ligature is then applied to both ends if the vessel is completely divided; but if it is merely punctured, the ligature should be placed at least an inch on the cardiac side of the wound.

Strict asepticism is of course necessary. The limb should be swathed in cotton and kept slightly elevated.

Should the condition of the limb indicate that the collateral circulation is insufficient to maintain its vitality, or if the accompanying vein be torn or large collateral branches have sustained damage, it is highly probable that gangrene will ensue, and immediate amputation is the wisest treatment. The question of amputation must, however, be determined on the individual merits of each case.

CIRCUMSCRIBED TRAUMATIC ANEURISM

Circumscribed traumatic aneurism may occur in one of two ways.

(1) An artery has been bruised, or merely punctured, and the wound has healed; but the cicatrix, not being strong enough to withstand the force of the blood pressure, gradually yields, and thus a sac is formed consisting at first of the weakened arterial coat and its sheath. As it increases in size it is strengthened by thickened connective tissue, which may ultimately alone form the sac, the original wall becoming absorbed through pressure. In this form there is no extravasation of blood, unless the sac ruptures. It is a true sacculated aneurism.

(2) A minute wound is made in an artery, and failing to heal, blood slowly escapes and distends the sheath, which is strengthened, as in the other case, by condensed connective tissue. In this form there is extravasation of blood from the first.

Signs.—The signs of circumscribed traumatic aneurism are similar to those of ordinary sacculated aneurism (see chap. ii. vol. iii.).

There is a local, pulsatile, and expansile tumour with a thrill and murmur. The tumour tends to increase in size and may rupture or suppurate.

Treatment.—The treatment is practically that of aneurism. If the vessel involved is a small one, the operation of Antyllus with excision of the sac should be performed; but if it is a large one, the vessel should be ligatured in its continuity. The ligature may be applied close to the sac (Anel's operation) since the artery is healthy.

If preferred, digital or instrumental pressure may be adopted instead of ligature.

If a circumscribed traumatic aneurism should rupture or show signs of inflaming, it should be treated on the same lines as a diffuse traumatic aneurism.

SIMULTANEOUS WOUND OF ARTERY AND VEIN—ARTERIO-VENOUS ANEURISM

When an artery and vein are simultaneously wounded, as was too frequently the case in former times when bleeding was commonly performed by unskilled persons, a permanent communication between them may result. The union may be direct (*aneurismal varix*), or a sac may intervene (*varicose aneurism*). Although commonly due to injury, arterio-venous communications may result from destructive inflammation, or may arise without obvious cause from atrophy and absorption of the opposed vessel walls. Veins pressed upon by the sac of an aneurism may adhere to it, and by giving way at the point of adhesion will establish permanent communication. Arterio-venous aneurism may be met with in any part of the body where an artery and vein are in juxtaposition. The progress and treatment of the two forms are very different.

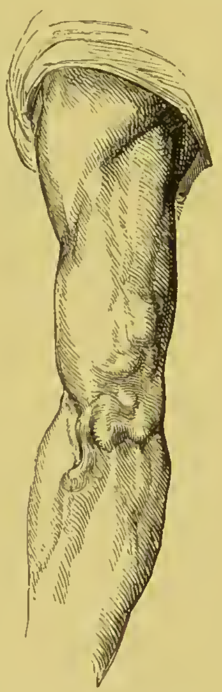


FIG. 14.—Aneurismal varix (Fergusson).

Aneurismal varix (Fig. 14).—The two wounded vessels unite by their opposed walls, but the openings remain patent, the blood flowing from the artery into the vein. There is no tumour as in the case of varicose aneurism. The vein, especially on the proximal side, is distended, thickened, and varicose, and opposite the artificial communication is pouched in consequence of the impact of the arterial blood; it pulsates like an artery. The artery above the opening is dilated and tortuous, and pulsates strongly; below it is contracted, since some of the blood has passed into the vein. The swelling is compressible and soft, and is made more prominent by a dependent position, less so by elevation; pressure on the distal end of the vein makes little or no difference, since the blood from the artery fills the vein above. There is a distinct thrill in the whole length of the vein, which is

much increased by gentle pressure over the site of the communication. A peculiar buzzing murmur, which has been likened to the noise a fly makes in a paper bag, is distinctly audible, and is sometimes so loud that it can be heard at a distance from the patient.

In old standing cases the skin may be harsher than natural and covered with coarse hairs. Aneurismal varix, after having attained a certain size, remains stationary.

Treatment.—As a rule, no treatment is necessary or advisable. If, for any reason, it is deemed necessary to attempt a cure, direct digital pressure over the opening should be tried; it often fails. Operative treatment consists in tying the artery above and also below in order to prevent reflux of blood through the distal end. The vein should not be interfered with.

Varicose aneurism (Fig. 15) is practically a circumscribed traumatic aneurism communicating with an artery and a vein. There is a distinct tumour, with expansile pulsation, a thrill, and bruit. The pulsation, thrill, and bruit are also present in the vein, which is thickened and varicose; but they are less marked than in the case of aneurismal varix, since part of the force of the blood current is lost in the intervening sac. The sac wall is formed of thickened connective tissue; the tumour is usually soft, as it contains but little fibrin. The tendency is to gradual increase of size and ultimate rupture.

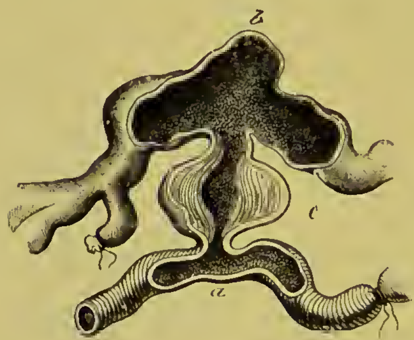


FIG. 15.—Varicose aneurism. *a*, artery; *b*, vein; *c*, aneurismal sac partly filled with blood clot (Follin).

Treatment is absolutely necessary in the case of varicose aneurism, since, if left alone, it will sooner or later rupture.

Pressure applied to the artery above, or directly over the tumour, may lead to permanent cure, as in the case of ordinary sacculated aneurism. Failing this, the operation of Antyllus must be performed, but it is never easy and may be extremely difficult. The following are the steps of the operation:—

A tourniquet having been applied, an incision is made through the skin and the vein exposed; this is then opened, the aperture of communication with the sac sought for and a probe passed through it. If any difficulty is experienced in finding this opening, or—in the later steps of the operation—in finding the artery, the

tourniquet is slightly loosened, when the stream of blood will indicate the position sought for. The probe being in the sac, this is laid open, any coagulum it may contain is cleared out, and the opening of the artery sought for. A probe being passed into the artery to indicate its position, the vessel is cleaned above the sac and ligatured. The distal end is then similarly treated.

If the vein is away from the line of incision the sac may be opened directly, the vein being left untouched.

Injuries of Veins

WOUNDS OF VEINS

Although the veins are more superficial and less protected than arteries, yet wounds of these vessels do not lead to such serious hæmorrhage or after effects. The blood-pressure in them being much less than that in arteries, and their walls being thinner, hæmorrhage is, except when occurring from very large trunks near the heart, much less profuse and more readily controlled. The injuries to which veins are liable are similar in nature to those affecting arteries. A wound of a vein, *e.g.* venesection, may, on account of the slight pressure on its walls, heal by first intention and without occlusion of its lumen. Spontaneous rupture may occur, as in thin-walled varicose veins. Subcutaneous rupture is also met with, *e.g.* scrotal hæmatocele.

AIR IN THE VEINS

Causes.—During inspiration there is negative or minus pressure in the veins of the neck and axillary region, and it sometimes happens in wounds of these vessels that air is sucked into them by the aspirating power of the chest. This region of the body has therefore been called the "dangerous area." In rare cases air has entered through small vessels, but the jugulars, subclavians, and axillaries are most to be dreaded. The external jugular, owing to its relation to the deep cervical fascia, does not collapse when cut low down, and this failure to close favours the entrance of air. Air may occasionally, though rarely, enter more distant veins.

This most serious accident is much more likely to occur if from any cause an injured vein is prevented from collapsing as it should do under ordinary circumstances. Incomplete division, or division

of a vein whose walls are thickened by disease, and thereby rendered rigid, favours the entrance of air. During the removal of tumours in the neck it not infrequently happens that a vein which is adherent to the mass is wounded, and such wound is held open (*canalisation of veins*) by the traction put upon the tumour to facilitate its removal; such a condition of things courts the occurrence of the accident. The deeper the inspirations the greater the suction action of the chest, and hence the more likely is the entrance of air; this should be remembered when the patient is under the influence of ether and is breathing deeply.

Pathology.—The air sucked into the vein passes to the right side of the heart, and being there churned up with the blood, a spumous, frothy fluid results. It is obviously necessary, for the due performance of its work, that the cavities of the heart should contain blood, and not a mixture of blood and air. Blood is an incompressible fluid, and the contraction of the heart is fully expended in maintaining the circulation; the valves are closed by the pressure of the column of blood. Air is capable of compression, and therefore, if the cavities contain blood and air, much of the force of the cardiac systole is wasted in compressing the latter; such force as remains acting on this mixed air and blood is incapable of closing the valves which flap back against the walls. The inability of the valves to act throws the cardiac mechanism out of gear and finally arrests its action. The impediment offered to the circulation on the right side of the heart also affects the lungs, which receive less blood, and through them the left cavities of the heart, and consequently general arterial anæmia supervenes.

Symptoms.—The entrance of air into a vein is signalised by a peculiar sucking or whistling sound, and the appearance of bubbles in the blood at the mouth of the vein. When a considerable quantity has gained admission the patient becomes deathly pale, and is seized with sudden and severe dyspnœa of cardiac origin; the respirations are hurried and shallow; there is a feeling of great oppression at the chest, the pulse is rapid, irregular, feeble, or almost imperceptible, the pupils dilate, convulsive movements often occur, and syncope ushers in death.

In fatal cases death may be practically instantaneous; should it be delayed it may occur from some secondary pulmonic or bronchitic inflammation.

When only a small quantity of air has entered the heart the symptoms, although similar in nature, will be less marked in severity, and recovery may occur.

Treatment.—A full knowledge of the conditions under which this dreaded accident occurs will enable the surgeon to adopt preventive measures during the performance of operations in the dangerous area. Great care should be taken to avoid wounding any vein, and if the division of one, however small, is unavoidable, it should, when possible, be secured by clamp forceps, then divided, and immediately ligatured. In the removal of tumours, it should be remembered that veins are frequently adherent to them, that their walls may have been thickened by disease, and thus complete collapse rendered impossible, and that undue traction on the mass may cause gaping of the vessel if wounded. In such cases it is best to carefully search for the veins, to separate them with the handle of the scalpel instead of by dissection, or, if it be found necessary to divide them, to apply clamp forceps before doing so.

Air having once gained admission, every endeavour must be made to prevent any more coming in, and, as far as possible, to get rid of that which has already entered. The finger should at once be placed over the injured vessel on its cardiac side, and the wound should be filled with fluid which effectually prevents further ingress of air; during expiration the finger should be removed from the vein and forcible compression of the chest employed as a means of facilitating the escape of air; as this occurs bubbles will be seen in the blood or fluid round the mouth of the vessel. Compression of the abdominal aorta, and axillary vessels, or elevation and bandaging of the limbs, has been suggested with a view to allowing more blood to go to the lungs and brain, and is certainly worthy of trial.

Artificial respiration seems of doubtful value, although it is stated to have been of use in the cure of animals, into whose veins air had been experimentally introduced; it may be pointed out here that there is plenty of air in the chest, the pulmonary symptoms being entirely due to deficient circulation and inefficient heart's action. Some consider artificial respiration to be actually harmful.

Brandy and diffusible stimulants may be given by the rectum.

Catheterisation of the auricle, with a view to allowing the air to escape, is useless, and may be very dangerous.

Hæmorrhage

The escape of blood from a vessel is known as hæmorrhage, but clinically the term is usually applied to external bleeding, internal hæmorrhage being known simply as extravasation, or

by some specific term indicating its position and source, *e.g.* hæmatemesis, hæmaturia.

Hæmorrhage may be traumatic or spontaneous; in the latter case it is dependent upon some antecedent change in the vessel wall whereby its strength has been impaired, and it is rendered incapable of withstanding the pressure of the blood-stream. Internal hæmorrhage is generally much more serious than external, since its exact seat, and the circumstances under which it occurs, cannot always be ascertained with certainty, and surgical means of arresting it are either impossible, or the amount of bleeding is so great, that a fatal termination ensues before any aid can be obtained.

The amount of hæmorrhage and consequent danger to the patient naturally depends upon the number, size, and character of the vessels injured, and the promptitude with which measures are adopted to arrest it.

The nature of the bleeding, the ease with which it can be arrested, and the choice of means to this end, differ in the case of arteries, veins, and capillaries.

Arterial hæmorrhage.—When an artery is completely divided, the blood, of a bright, scarlet colour, flows from the proximal end in a stream of intermittent force, a jet issuing at each cardiac systole. Succeeding jets are smaller and less forcible (1) from failure of the heart's action; (2) because the muscular and elastic tunics of the vessel contract and narrow its lumen; (3) from clotting of the blood. Very little blood escapes from the distal end of the vessel, and what does come simply wells up instead of flowing *per saltum;* if, however, the anastomoses are very free, as in the case of the facial, or if there is a large branch close to the distal end of the divided vessel, the bleeding may be characteristically arterial. Hæmorrhage from small arteries may be spontaneously arrested.

Venous hæmorrhage is, unless a very large trunk be wounded, less serious and more easily arrested than arterial. The blood escapes in a continuous dark, maroon-coloured stream, and not *per saltum;* it escapes from the distal side, and the flow is increased by pressure on the cardiac.

In deep narrow wounds it is sometimes very difficult to tell whether bleeding is arterial or venous since the character of the stream cannot be determined, and the colour of venous blood may be lost by contact with the air. Under such circumstances, we may infer that an artery has been wounded if pressure on the cardiac side of the wound arrests the bleeding; if, however, this

increases it, and it is arrested only by pressure on the distal side, the bleeding is venous; diminution of the hæmorrhage by pressure on one side, and arrest with simultaneous pressure on the other, point to injury of both vein and artery.

Capillary hæmorrhage.—Bleeding from minute arteries, veins, or capillaries occurs as general oozing from the surface. The blood is intermediate in colour between arterial and venous. In the case of wounds, the hæmorrhage is usually slight in amount, and stops readily and spontaneously when the wound is freely exposed to the air. Capillary bleeding is profuse and persistent from tissues which are the seat of chronic thickening through inflammation or infiltration by a new growth, or in which, owing to their natural density, retraction of the vessels is difficult. Capillary oozing may also be very copious from granulating surfaces, and from large abscess cavities. In the subjects of hæmophilia it is most profuse and dangerous.

Primary hæmorrhage is that which occurs at the time of injury.

Reactionary or intermediary hæmorrhage occurs within the first twenty-four hours, as soon as shock is passing off and reaction begins. Small vessels which ceased bleeding spontaneously at the time of an operation may, as soon as the heart-beat becomes stronger and more forcible, bleed anew, the clots in the divided ends being unable to withstand the *vis â tergo*. Reactionary hæmorrhage may also be due to the slipping of a ligature.

Secondary hæmorrhage occurs any time after the first twenty-four hours, but usually from the seventh to the tenth day. Its causes, pathology, and treatment will be discussed in detail subsequently (p. 84).

The constitutional effects of hæmorrhage.—The general effects of hæmorrhage depend upon the amount of blood lost, the rapidity of the loss, and the age and general state of the patient.

Rapid and sudden bleeding, such as occurs when a large vessel is wounded, or after child-birth, is much more dangerous, and is accompanied by more urgent symptoms than is prolonged hæmorrhage, even if in the latter case the total amount of blood lost be greater.

At the two extremes of life, and in those debilitated by disease or excess, the loss of blood is badly borne. In healthy persons the effects of copious hæmorrhage usually pass off rapidly, though in some cases the patient may remain exsanguined and weakened for many months. Prolonged and repeated hæmorrhage, *e.g.* hæmop-

tysis, etc., is dependent upon some chronic disease, and unless this can be remedied the patient's strength is gradually undermined and profound anæmia results.

A patient who has suddenly lost a large amount of blood will show unmistakable signs of it. The skin is pale and covered with a cold sweat, the extremities are cold, and the finger-tips and mucous membranes assume a livid tint from imperfect venous flow owing to weakened heart's action and diminished *vis à tergo.*

The breathing is feeble and sighing, and the patient, with a sense of impending respiratory paralysis, begs for air. The voice is feeble and low, and muscular debility is extreme. In the worst cases the patient is restless, tosses about on the bed, throwing his arms now over his head, now by his side. Marked restlessness and jactitation are serious omens.

The heart's action is enfeebled, rapid, and perhaps irregular; the pulse is soft, easily compressible, and dicrotic. In cases of impending hæmorrhage the pulse may be rapid and hard.

Faintness or actual syncope is quickly induced by severe hæmorrhage, as the brain loses its due supply of blood. Syncope is also caused, in many cases at least, by the mental shock occasioned by the injury or the sight of blood. Fainting, by lessening the force of the circulation, tends to arrest the bleeding, and attempts to restore the patient to a state of consciousness should not be too readily or zealously undertaken.

Thirst, dimness of vision, buzzing in the ears, and convulsions are all present in severe cases. When the loss of blood occurs slowly the symptoms, although of the same nature, come on more gradually, and quite frequently the patient complains of drowsiness from cerebral anæmia.

The spontaneous arrest of hæmorrhage.—Hæmorrhage from vessels even as large as the radial artery may cease spontaneously, and in larger ones the blood flow is much diminished, although not actually arrested.

Such a happy event can only occur if the wound be very small, or the vessel completely divided; for, as already shown in considering the wounds of arteries, incomplete division promotes rather than hinders hæmorrhage, since the retraction of the arterial coats enlarges and keeps open the orifice of the wound. The nature and shape of the wound in the surrounding soft parts may favour the spontaneous cessation of bleeding; thus in the case of lacerated wounds the vessels are frequently twisted and but little blood is lost. Again, if the wound be narrow, tortuous, or deep, the blood, having no free

exit, coagulates, the coagulum being supported by the tissues. The means adopted by Nature for arresting hæmorrhage are as follows :—

Temporary means.—All arteries are normally in a state of circumferential and longitudinal tension, and, when divided, tend to contract and retract within their sheaths.

Contraction of the muscular and elastic tunics narrows the mouth of the vessel, even obliterating it if it is small, and is an important factor in arresting bleeding. It is due, partly to the natural resilience of the arterial wall, partly to the stimulus afforded by the injury and by exposure to the air.

A vessel, being longitudinally stretched, *retracts*, immediately it is completely divided, within its sheath and its open mouth is embedded among the tissues, a certain amount of resistance being thus offered to the escaping blood-stream.

Contraction and retraction cannot occur efficiently unless the vessel is completely severed; if it be merely wounded in part of its circumference the wound is made larger and the hæmorrhage proportionately increased. Diseased vessels are unable to contract, and those embedded in resisting structures, or which have become adherent to the parts around, retract imperfectly or not at all.

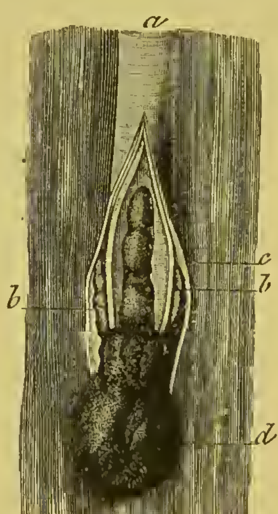


Fig. 16.—The temporary arrest of hæmorrhage. *a*, artery; *b*, clot between the artery and its sheath; *c*, *d*, blood clot separable into two parts—the larger blocks the mouth of the vessel, the rest is conical in shape and extends into the lumen (Follin).

The bleeding from the perforating arteries in amputation at the middle of the thigh often gives considerable trouble, since they run in dense fibrous tissue close to the linea aspera, and are therefore prevented from retracting to the full extent of which they are capable.

Coagulation of the blood is a most important element in arresting its escape. As hæmorrhage continues the coagulability of the blood seems to be increased; in addition, the weakened action of the heart, by *lessening the vis â tergo*, favours the formation of clot and prevents coagula from being washed away by the escaping stream. A coagulum forms round the mouth of the divided vessel, between it and its sheath, which presents a roughened surface, and in the surrounding soft tissues, so that the channel of escape is narrowed and the mouth of the vessel supported (Fig. 16). This is called the external coagulum. The internal

clot forms in the lumen of the vessel; it is gradually deposited on the wall, and consequently the stream of blood is diminished in size until, finally, clot fills the vessel and bleeding is arrested. If, however, the force of the heart beat is increased as the patient recovers from syncope or shock, the clot, unable to withstand the force of the blood stream, may be washed away and additional bleeding is the result (intermediary hæmorrhage).

Hæmorrhage being temporarily arrested in the manner described, certain changes occur in the clot and the vessel wall leading to permanent closure and obliteration.

The permanent closure of wounded vessels.—The processes which lead to permanent closure of a wounded vessel have been carefully investigated by experimental ligation followed by *post-mortem* examination. The most important recent work on this subject has been undertaken by Ballance and Edmunds and is embodied in their admirable work on *Ligature in Continuity*.

The ultimate changes in vessels undergoing closure are the same in all cases, whether they have been accidentally or purposely divided and ligatured, or whether they have been ligatured in their continuity without division, or indeed have received any injury leading to permanent occlusion. It will be convenient in this account to assume that an artery has been ligatured in its continuity; but it must be remembered that the process is the same under all circumstances, whether in arteries or veins, the only difference being that in the latter the obliteration is usually accomplished more rapidly, since the blood pressure is less, and hence the constructive process has less chance of being interfered with. Wounded veins may heal without permanent obliteration of their lumen, as in the case of venesection. Formerly it was considered essential that, for ligature to be safely performed, the middle and internal coats of the vessel should be ruptured; it is now recognised that this is not only needless but should be avoided. If the coats are ruptured they contract and retract within the outer and form a more or less complete valve (Fig. 13, p. 57). When a ligature has been applied to an artery in its continuity, a clot forms on the proximal and distal sides, theoretically reaching to the nearest collateral branch, but practically often falling short of this point, especially in the larger vessels. If the coats have been ruptured by the ligature the clotting is more extensive, but whether ruptured or not there is usually quite sufficient clot to offer an effective buffer to the force of the blood current. In rare cases there may be no coagulum formed. Clotting on the distal side of the ligature is always less extensive than on the proximal, nor is there

the same need for it, as the blood stream on the distal side is much less powerful. On the proximal side the clot appears to cause a dilatation of the vessel (*Bryant's ampulla*), but this is an appearance only; the real fact being that the vessel beyond is somewhat contracted, this contraction being permanent if the obstruction is (as it should be after ligature) also permanent. The formation of the coagula in the vessel is the result of the altered vital state of the walls consequent on the injury caused by tightening the ligature. The coagula are conical in shape, completely filling the vessel at their bases, *i.e.* near the ligature, but gradually tapering and ending in free extremities at the apices (Fig. 17), which are in contact with flowing blood. The clot is not uniformly attached to the intima, but only here and there; and in those parts where there is no attachment, a thin layer of fluid blood, in connection with that still circulating, passes between the vessel wall and the coagulum. The blood clot is gradually deposited from the time the ligature is applied, and is stratified, the central portions being the oldest; it may or may not contract, and, as has been shown by Lister, does not as a rule do so in aseptic wounds.

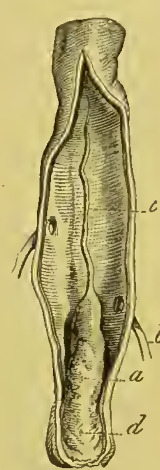


FIG. 17.—The clot on the proximal side of a ligature. *a*, clot; *b*, collateral branches of the vessel; *c*, tapered end of the clot; *d*, part at which the clot is adherent to the vessel wall (Follin).

The formation of the clots is of the utmost importance, although they play a purely passive part and must be regarded as foreign material. They offer a temporary support against the force of the blood-current, and, as will presently appear, afford as it were a scaffolding in which the cells, destined to permanently obliterate the vessel, may build up new connective tissue; they also serve as food for the formative cells.

A few days after its formation, the blood clot is traversed by fissures and clefts which divide it up into definite minute areas (Fig. 18, p. 72). These spaces afford easy ingress to the plasma cells from which the new connective tissue is formed; moreover, by this invasion of plasma cells throughout the clot it is attacked from all sides and destroyed piecemeal. A fibrin network forms in the clot and pervades it, and along the paths of this network the plasma cells penetrate its substance.

These cells are derived by rapid and profuse proliferation of the endothelial cells of the intima, which is consequently thickened.

The changes in the intima are noticeable as far as the clot extends. The invasion of the blood-clot by leucocytes, and later by the plasma cells, causes it to become paler in colour; from chocolate it becomes gray as infiltration proceeds. The plasma cells ingest the clot and take its place (Fig. 20, p. 74), and there is good reason to believe that they bring about this destruction by secreting some ferment causing disintegration of the red cells. At quite an early stage the clot becomes vascularised; some of the new vessels are formed from columns of plasma cells, which become vacuolated

FIG. 18.—The carotid of a sheep three weeks after ligature. In the lower part of the figure is seen the middle coat; above that the white line shows the membrane of Henle; above that, again, a darker band is the thickened intima; the remainder of the figure is coagulum; this is a recent clot which has been deposited between the original clot and the vessel wall. The coagulum is fissured by a mechanical or chemical process, and, near the endothelium, corpuscles may be seen invading it along the cracks and fissures (Ballance and Edmunds).

(Fig. 21, p. 75). New capillary loops are also formed from the vasa vasorum of the vessel walls. The blood circulating in these new vessels is derived from that in the proximal end of the vessel if it be an artery, from the distal end in the case of a vein. According to Ballance and Edmunds, circulation through these new vessels is established by the end of the third or early in the fourth week (Fig. 20, p. 74).

While these changes are occurring within the lumen of the vessel, no less important ones may be observed in the coats and externally. The ligature is quickly enveloped in plastic exudation; and the vessel walls, the circulation through which has been inter-

fered with by the pressure of the ligature, become infiltrated with new cells derived by multiplication of the original cellular elements.

This plastic exudation, infiltrated with plasma cells, becomes vascularised in five or six days—much earlier, it will be noted, than does the internal coagulum, since the vital condition of the surrounding tissues is better. As development of the new cells proceeds, the whole mass is converted into fibrous tissue, similar in every respect to that constituting a scar in any other tissue of the body.

When obliteration is complete, the whole forms a mass of pale

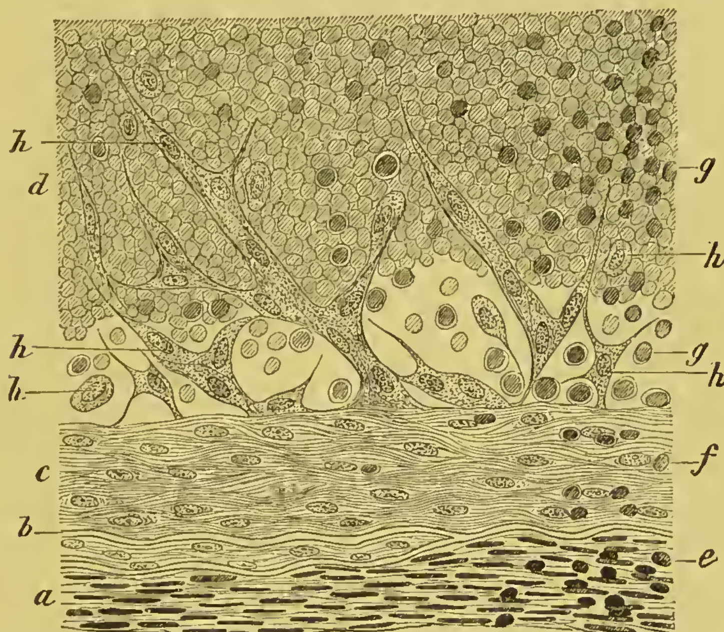


FIG. 19.—Section of a thrombus in process of organisation. (From the femoral artery of an aged man three weeks after ligature; hæmatoxylin staining. × 350.) *a*, tunica media; *b*, fenestrated elastic membrane; *c*, intima thickened by previous inflammation; *d*, coagulated blood; *e*, cells infiltrating the media; *f*, cells infiltrating the intima; *g*, leucocytes, partly within the thrombus, partly between it and the intima; *h*, various kinds of formative cells.

cicatricial tissue which gradually contracts and dwindles until the vessel is represented by a thin fibrous cord. The muscular coat of the vessel, being no longer needed, undergoes atrophy and absorption.

The behaviour and fate of the ligature will be subsequently referred to (see Ligature of Arteries, vol. iii.).

Deviations from the normal process of permanent closure.—For the permanent obliteration of an artery or vein, it is necessary that the wound should be aseptic and free from all sources of irritation; that the ligature should be tightened sufficiently to occlude the vessel

but not to injure the walls unduly; that the walls themselves should be healthy, and the ligature of a harmless nature. If any injurious influence be brought to bear upon the seat of ligature, the inflammation may run an acute course terminating in suppuration; the seat of ligature, being bathed in pus, is thus deprived of the support it would otherwise have from the plastic exudation, and the internal changes alone must be relied on for permanent obliteration.

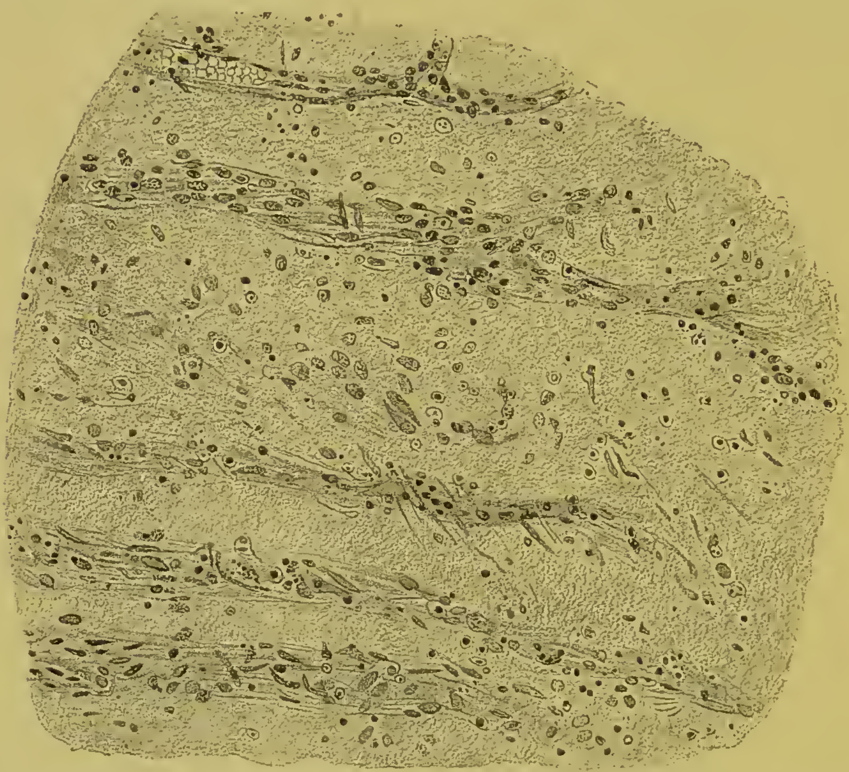


FIG. 20.—Blood clot from the peritoneal cavity. The specimen was obtained from the abdominal cavity of an animal into which a large quantity of blood had been injected ten days previously; the drawing was made from a small clot, its adherent border is to the left. The outline of the red corpuscles can no longer be seen; plasma cells are scattered throughout, but are specially arranged in linear masses which are about to form capillaries, indeed, in the uppermost, circulation has already commenced, as shown by the blood within it (Ballance and Edmunds).

Should these internal changes prove insufficient, or should the suppurative process extend to the vessel wall, rupture may occur and secondary hæmorrhage result. This is more likely to occur on the distal side, since the internal changes are, as already stated, less perfect here than on the proximal. The proximity of a large branch may, by limiting the amount of internal coagulum, also lead to secondary hæmorrhage from giving way of the artery under the force of the blood stream. It may happen that although the

coats of the vessel do not give way and produce secondary hæmorrhage, yet permanent occlusion of the vessel does not result, and the circulation is re-established. This may be due to imperfect tying of the knot, so that the lumen of the vessel is not quite occluded by the ligature; or, though this has been quite tightly tied, it may have become too rapidly absorbed, and thus the lumen of the artery reopened. Re-establishment of the circulation may also occur at a later period by canalisation of the coagulum or by gradual absorption of the clot and young fibrous tissue, the new vessels in which carry on the collateral circulation.

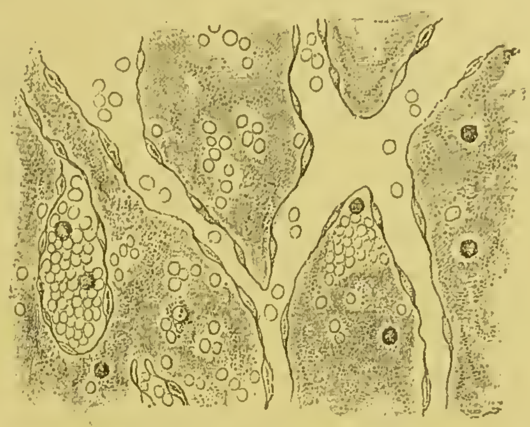


Fig. 21.—The newly-formed capillaries in a thrombus Spindle-shaped plasma cells encapsule each district of the clot, and at the same time form a plate of cells which bound the channels through which the circulation of the blood is first established. The red corpuscles are no longer recognisable in the districts of the clot, their place being occupied by a granular material (Ballance and Edmunds, after Thoma).

If the ligature has not completely occluded the vessel, or has been absorbed too rapidly, a diaphragm with a central hole through which the blood flows may form at the point of ligature. The diaphragm may be formed by the recurved inner and middle coats, if they have been ruptured, but in most cases arises from proliferation of the intima.

The treatment of hæmorrhage.—The treatment of hæmorrhage must be to all surgeons a matter of the first importance. Profuse bleeding, which may prove fatal unless promptly arrested, must occasionally occur in the experience of all, and is one of the greatest and most trying of surgical emergencies, inspiring as it does both patient and bystanders with the utmost dread so that the surgeon is too often left to grapple with the situation single-handed. Coolness of judgment, prompt action, and readiness of resource are essential; hurry and excitement must be strenuously avoided. Since the introduction of the bloodless method of operating there are but few operations in which hæmorrhage need be dreaded, and in these cases skilled and sufficient assistants, each of whom has his allotted duty, reduce the anxiety of the surgeon to a minimum.

Hæmorrhage is most to be dreaded when the source of it is

concealed; no surgeon need fear even the smartest bleeding if the vessel be accessible and he can look the danger in the face.

Temporary means.—It often happens in the case of accidents that severe bleeding occurs which must be temporarily checked while preparations are being made for the removal of the patient and for dealing with the injured vessels. For this purpose pressure, either on the bleeding point, or at a distance, is *the* remedy. The source of the bleeding, whether it be arterial or venous, must be determined in the manner described on p. 66.

If the vessel be readily accessible, direct digital compression will immediately arrest the blood flow; if, however, the wound is of such a nature, *e.g.* compound fracture, that this cannot be done, a tourniquet, which can be readily improvised, must be applied (Fig. 22). A tourniquet may be made in the following way:—A long handkerchief is passed round the limb; underneath it (in the line of the bleeding vessel if this can be determined) is placed some hard substance, *e.g.* a stone or piece of wood, wrapped in a second handkerchief so that the skin may not be bruised; the first handkerchief is then tied tightly round the limb. A piece of cord, a waist-belt, or braces will answer the purpose equally well. If sufficient pressure is not obtained by tying the encircling band, a piece of stick should be passed between it and the skin and then twisted until the bleeding is arrested.

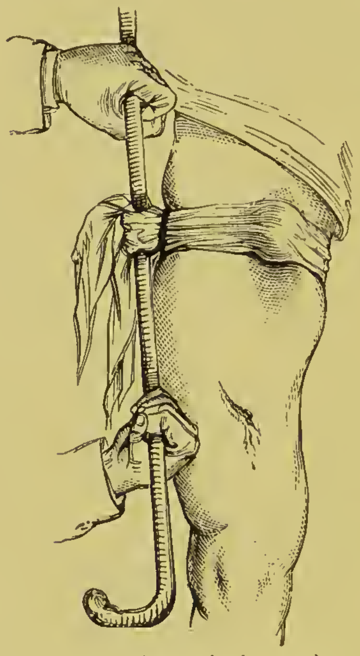


FIG. 22.—An improvised tourniquet (Berkeley Hill).

If the bleeding is venous, pressure must of course be applied on the distal side, if arterial, on the cardiac.

If the patient has lost a large quantity of blood, he should be placed flat upon his back with the head depressed; the limbs should be raised and may be bandaged to promote the flow of blood to the brain. Plenty of fresh air should be given. Ammonia and ether, which may be injected under the skin over the cardiac area, may be necessary to stimulate the action of the heart in very bad cases; but as a rule stimulants should be avoided, since the increased action of the heart induced by them may cause additional hæmorrhage;

this, however, is of no importance if the bleeding has been arrested by local means.

When the bleeding has been so profuse that the patient is actually dying from want of fluid in his vessels, intravenous injection must be resorted to (see p. 87).

Local permanent means of arresting hæmorrhage.—*Hæmostatics* are agents whose action on the vessels promotes some or all of those processes by which bleeding is spontaneously arrested. Those chiefly employed are as follows:—

Cold.—Cold excites contraction of the muscular tunic of the vessels, and of the surrounding tissues, so that the orifice and track through which the blood escapes are narrowed. The contraction is only temporary, being succeeded by relaxation and loss of tone; hence cold can only be relied on in capillary hæmorrhage.

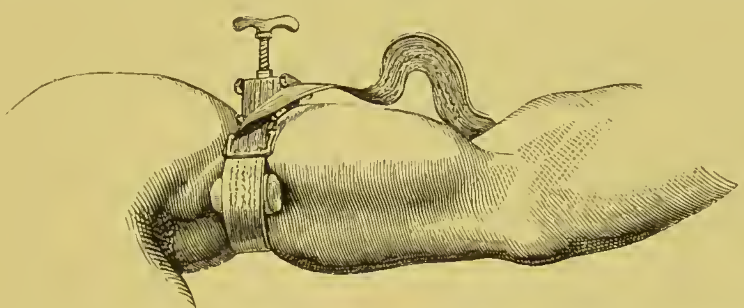


FIG. 23.—Pettit's tourniquet applied to the upper end of the brachial artery (Fergusson).

Exposure of a wound to cold air causes a marked diminution of the oozing. Cold is applied by means of ice-cold water or small pieces of ice; it is especially useful in bleeding from the mouth and nose, uterus, rectum, bladder, and stomach.

Hæmorrhage from the middle meningeal artery after trephining may be arrested or held in check by the application of a freezing mixture of ice and salt to the injured side of the head and neck.

Hot water.—Water at a temperature of 120° to 150° F. is very efficacious in capillary oozing. It acts by causing contraction of the involuntary muscular fibres of the vessels; such contraction is stronger and more permanent than that induced by cold, and is not followed by the same loss of tone. In *post-partum* hæmorrhage, hot water injected into the uterus acts by inducing muscular contraction and consequent closure of the venous sinuses.

To be effectual the water must be at the temperature stated, for if it be only warm it will increase the bleeding. It is applied

by means of sponges held in forceps, the heat being too great for the fingers. The wound is in no way damaged by this temperature, and union by first intention will ensue.

Hot water applied to a large wound serves to stimulate the patient, whereas cold rather depresses.

Styptics act by increasing and hastening the coagulation of the blood; some also stimulate the vessels to contract. The use of styptics should be reserved for those cases of hæmorrhage in which all other means fail or are inapplicable, since they have an injurious effect upon the tissues, lowering their vitality and consequently interfering with the rapid healing of the wound. The degree of irritation caused by styptics is such that severe inflammation may occur, followed by suppuration and sloughing, with their attendant dangers, including secondary hæmorrhage. In cases of internal hæmorrhage, *e.g.* hæmaturia, hæmatemesis, etc., styptics are often very useful, and indeed may be the only means of checking the bleeding at our disposal; in such cases, the method of using the drugs varies with circumstances. Styptics should never be employed in parts rich in loose cellular tissue, *e.g.* the palm, perineum, scrotum, face, and neck, as in these places they are very liable to set up diffuse destructive inflammation.

Whenever a styptic is to be applied to a wound, the blood clots should be removed and the surface dried as far as possible by sponging so that the application may be made directly to the bleeding vessels. This should be done in the following way:—Strips of lint soaked in the styptic solution being ready at hand, the wound is cleansed by sponges rapidly replaced by others so as to control the bleeding; the clots having been removed, the sponges are replaced by the strips of lint which are then held in position, and if necessary retained there by bandages for some hours, until there is no fear of further hæmorrhage. If the styptic has been effectual no further sponging is permissible, otherwise the clots in the vessels upon which the arrest of bleeding is dependent may be dislodged. The drugs usually employed are as follows:—

Turpentine is one of the most powerful and valuable styptics at our command. It may be applied locally, and is very efficacious in secondary hæmorrhage when other means fail. Administered internally in half drachm doses made up with mucilage of acacia, turpentine arrests hæmorrhage from the kidney, having probably some direct action on that organ. Its effects must be carefully watched, since the drug sometimes excites renal congestion. Tur-

pentine may also be given by the stomach in hæmatemesis and hæmoptysis, and in the latter case by inhalation also.

Perchloride or persulphate of iron are commonly used, but they have the great disadvantage of causing considerable damage to the tissues, and of forming tough adherent coagula which separate slowly and are liable to undergo putrefactive decomposition. The persulphate is less irritating to the tissues than is the perchloride, but the latter is more generally used in this country. For general use, one part of the Liq. ferri perchloridi may be added to three of water, and strips of lint soaked in it may be applied to the bleeding area. If, as in the case of *post-partum* hæmorrhage, the fluid is to be injected, it should not be stronger than 1 : 6 or 1 : 10; in this case the uterus must not be kneaded after the bleeding has been arrested by the styptic for fear of dislodging the clots from the venous sinuses. The pure liquor is occasionally used.

Absolute alcohol causes contraction of the vessel-walls and hastens coagulation. It is very useful as a styptic in arresting oozing from abdominal adhesions during the removal of tumours.

Alum, matico, gallic and tannic acids, benzoin, styptic colloid, hamamelis, chloride of zinc, and nitrate of silver are also sometimes used as styptics. They are powerful astringents, causing contraction of the vessels and inducing coagulation. Of these alum is the best for general purposes; it should be applied as a hot saturated solution, the crystals are then deposited round the open vessels as cooling takes place and the full action of the drug is obtained.

Gallic and tannic acids (4 grs. ad ℥i.) are powerful local astringents; they may also be given internally in bleeding from the intestinal tract. Locally they are but little used. Hamamelis is useful in bleeding from the rectum; it should be used as an injection, one drachm of the tincture being added to every ounce of cold water. Given internally it does good in intestinal hæmorrhage.

Chloride of zinc (grs. 40 ad ℥i.) is useful to check oozing during operations; it is a powerful antiseptic, and although it whitens the tissues, does not interfere with healing by first intention. Nitrate of silver is but little used; persistent bleeding from a leech-bite may sometimes be controlled by inserting a point of the solid salt into the wound.

Internal and subcutaneous administration of hæmostatics is resorted to in cases of internal hæmorrhage and bleeding from the uterus. Taken by the mouth, turpentine, hamamelis, ergot, opium, acetate

of lead, and sulphuric acid—the last three frequently in combination—are the most usual remedies; subcutaneous injections of ergotine or sclerotic acid act more quickly.

These drugs cause contraction of the small vessels and increase the general blood pressure; they should therefore not be used if there is reason to suppose that the blood is coming from a large vessel. In *post-partum* hæmorrhage, ergot or sclerotic acid act beneficially by causing contraction of the uterine wall.

The actual cautery was formerly extensively used as a means of arresting hæmorrhage. In ancient times, amputations were performed with red-hot knives, and quite recently the galvanic ecraseur was used by many surgeons for removal of the tongue, but is now generally abandoned. For the removal of elephantiasis and very vascular tumours the cautery is still sometimes employed.

Pacquelin's benzine cautery is the most convenient instrument for the purpose. It should be at a dull red heat; if heated beyond this it destroys the tissues too much and fails to stop the bleeding. Application of the cautery to a vessel forms a charred mass which blocks its mouth, and in some cases causes retraction of the inner and middle coats which curl up and form a more or less complete valve. The disadvantage of the cautery is that when the slough separates secondary hæmorrhage may occur, and, moreover, it interferes with the proper and speedy union of the wound. It is useful in arresting bleeding from the medullary artery of bones, and being, in this case, very limited in its action, does no harm. Secondary hæmorrhage from rotten and sloughy wounds, when the tissues will not hold a ligature, may necessitate the use of the actual cautery.

Mechanical means—*Position.*—Elevation lessens the flow of blood from the arteries and veins, and in the case of the latter may actually stop it.

Extreme flexion of a joint arrests the circulation in the vessels below and may be useful as a temporary means of arresting hæmorrhage.

Compression has already been referred to as a temporary means of arresting hæmorrhage; in some cases it is relied upon to procure permanent effects. Pressure is obtained by the finger, by tourniquets, pads, tampons, or by means of a graduated compress. It must be remembered that pressure more or less completely exsanguinates the whole area compressed, and consequently may, if too long continued, lead to sloughing or gangrene. Bleeding from the vessels of the scalp, from the kidney in operations, from leech

bites, and in cases of capillary oozing, can usually be arrested by pressure maintained for a few minutes.

Tampons made of lint or cotton-wool are very useful for plugging the posterior nares, the rectum, vagina, or uterus, or for deep wounds which it is unadvisable to enlarge. Pressure should never be relied upon, except as a temporary expedient, in cases of bleeding from a large vessel.

Some surgeons rely on pressure as a permanent means of arresting deep hæmorrhage from the palm or sole (p. 143).

Forci-pressure is a most useful method for dealing with small vessels during the performance of an operation. The vessel is caught with a pair of Spencer Wells's forceps, which are then tightly closed, so as to crush its end; the instrument is left on for a few minutes, and may be twisted once or twice before removal, in order to give additional security. In very deep wounds, where there is much difficulty in securing the bleeding vessel, and in which the application of a ligature is impossible, the forceps may be left on for twenty-four hours.

Forci-pressure acts in the same way as torsion.

Acupressure is now practically obsolete. In the operation for hare-lip, bleeding from the coronary is prevented by acupressure, the sutures being passed so as to compress the artery. Acupressure needles should not be left in for more than two days, or they may give rise to irritation and resulting scarring; for these reasons the method is only applicable to small vessels, and even in them may be followed by secondary hæmorrhage, if the internal changes in the vessel have not proceeded far enough to safely occlude it. Troublesome bleeding from a leech bite may be at once arrested by acupressure.

Torsion.—In lacerated wounds it sometimes happens that even the largest arteries do not bleed, as they have undergone natural torsion. There is no doubt that torsion, properly carried out, is a perfectly effectual means of closing a vessel, and some surgeons prefer this method to the application of a ligature, claiming for it certain advantages which are, however, more apparent than real. It is contended by those who practise it that torsion is more rapidly performed than ligature, though most surgeons would find this contrary to their own experience; furthermore, that it is a more exact imitation of what happens in nature, that it does away with the presence of a foreign body (which a ligature is), and that it is less likely to be followed by secondary hæmorrhage. Although these objections might have held good before the days of anti-

septics, and when ligatures were imperfect or carelessly used, they fall to the ground at the present day; moreover, torsion causes more damage to the vessel walls than does a carefully applied and suitable ligature.

Torsion is thus performed: the end of the vessel is grasped with forceps, which should be broad enough to secure it firmly, and with teeth not sharp enough to cut the coats; the vessel is then drawn out from its sheath, and freed from the surrounding structures, and slowly twisted, either until the end held by the forceps is twisted off (*free torsion*), or until a sufficient number of turns (usually eight or ten, according to the size of the vessel) have been given to ensure that the external coat will not uncoil when released (*limited torsion*).

By this procedure the inner and middle coats are ruptured, and retract within the outer, forming a valvular obstruction; the outer coat is twisted into a knot, and drawn out to a point.

Ligature is the easiest, safest, and most universally adopted method of arresting bleeding (see the Ligature of Arteries, vol. iii.).

After-treatment of severe hæmorrhage.—Patients who have suffered severely from hæmorrhage often remain ill and weak for months, and require building up during the period of convalescence. For this purpose complete rest of mind and body is essential, coupled with good and sufficient food, fresh air, and tonics. The astringent preparations of iron, bark, quinine, and ammonia are especially valuable. Port wine, Burgundy, and malt liquors—especially stout, if it agrees with the patient—must be given in sufficient quantities.

The treatment is practically that of anæmia.

THE TREATMENT OF PRIMARY ARTERIAL HÆMORRHAGE

There are certain well-recognised rules which should be followed in the treatment of primary hæmorrhage; these rules will be enunciated and severally considered.

1. *No attempt should be made to secure a vessel from which primary hæmorrhage has occurred, provided the bleeding has ceased spontaneously.*

Under such circumstances no further bleeding may occur, and attempts to find the vessel may prove fruitless and harmful. If, however, the wounded vessel can be seen pulsating, and is readily accessible, there is no harm in applying a ligature—indeed, it is a wise precaution.

While non-interference is the rule, every precaution must be

taken against recurrent bleeding. The limb should be elevated and kept warm by wrapping it in cotton wadding, and a tourniquet should be adjusted above the wound, so that if hæmorrhage sets in, it may be at once arrested by tightening the tourniquet. A reliable assistant should remain by the patient to render help if required.

2. *If bleeding is still going on when the patient is seen, both ends of the divided vessel must be secured; and if the wound has only partially severed it the artery must be cut across.*

The distal end of the vessel should be carefully ligatured, so as to minimise the risk of intermediary or secondary hæmorrhage.

3. *If the wound is small, so that the artery cannot be reached, it should, with but few exceptions, be enlarged, and the vessel sought for and tied where injured.*

If the rule of tying a vessel at the spot injured be not followed, and it be secured in its continuity, we may find that as soon as the collateral circulation has been established fresh bleeding will occur at the point of injury, necessitating ligature here after all. This method of treatment, whether successful or not, necessitates the obliteration of the vessel at two points, and so greatly enhances the risks of gangrene. Moreover, it is not always easy to determine, unless it be cut down upon, from which vessel the blood is escaping; consequently the wrong one might be ligatured in continuity. A minor objection lies in the fact that ligature in continuity necessitates the infliction of another wound, and is, in many cases at least, a more lengthy and difficult proceeding than is enlarging the wound.

If it is found necessary to enlarge the wound, this should be carefully done as nearly as possible in the line of the vessel supposed to be injured.

4. *If for any reason it be deemed inexpedient to enlarge the wound and tie the vessel* in situ, *it must be ligatured in its continuity.*

In certain situations arteries are so deeply placed, or run among such important structures, that the patient's best interests are consulted by ligaturing in continuity; thus the deep palmar arch, lying, as it does, beneath important vessels, nerves, and tendon-sheaths should not, when injured, be cut down upon, but the brachial should be ligatured (p. 143). Some surgeons advocate and practise the use of a graduated compress in wounds in this situation. The same remarks apply to wounds of the deep arteries of the neck, mouth, tonsil, etc., in bleeding from which a ligature should be placed on the branch at a distance, or on the external carotid.

THE TREATMENT OF INTERMEDIARY HÆMORRHAGE

The treatment of intermediary hæmorrhage is practically that of primary. It is never very severe, as it only occurs from the smaller vessels. If it is merely oozing, well-applied pressure will suffice to arrest it; but if more serious, the wound must be opened up, the clots removed, and the bleeding vessel sought for and tied. The wound should be cleansed, re-sutured, and dressed as before; as the bleeding occurs within a very few hours of the infliction of the injury, healing will not be interfered with.

SECONDARY HÆMORRHAGE

Secondary hæmorrhage may occur any time after the first twenty-four hours, and has been met with as late as three months; usually, however, it takes place between the seventh and twenty-first days. It may be generally stated that secondary hæmorrhage *may* occur so long as the wound remains unhealed. Since the introduction of antiseptics and improved forms of ligature, secondary hæmorrhage has become a rare occurrence.

Causes.—There are certain constitutional states which, by impairing the vitality of the tissues, and hence interfering with the processes of repair, predispose to secondary hæmorrhage. Chief among these are diabetes, Bright's disease, and chronic alcoholic poisoning. The local causes may have their origin in imperfections in the wound, the vessel, or the ligature.

Suppuration or sloughing arising from want of observance of ordinary antiseptic rules, from some septic or infective process, or from any other cause are powerful factors in inducing secondary hæmorrhage. The suppurative process may, by destroying the tissues surrounding and supporting the vessel, or by actually implicating and softening its walls, cause it to rupture.

During the operation of ligature the arterial coats may have been accidentally damaged above the point of ligature, or the vessel may have been stripped too freely from its sheath, and, being thereby deprived of its blood supply, may inflame and rupture.

The proximity of a large branch is said to predispose to secondary hæmorrhage by limiting the extent of the coagulum which offers a temporary barrier to the blood flow; but it is probable that if strict asepticism is observed, ligature near a main branch is in the majority of cases a perfectly safe procedure.

If unnecessary damage is inflicted by the ligature on the arterial

coats, they may subsequently soften and give way, especially at the seat of the knot.

Diseased vessels are more prone to be the source of secondary hæmorrhage than are healthy ones. Atheroma and calcification are not equally dangerous in this respect, for in the latter the outer coat, upon the integrity of which the safety of the vessel depends, is not diseased, as it frequently is in the former; moreover, the vessel is narrowed and contains less blood, and hence the force of the circulation is diminished. Even diseased vessels may, in the majority of cases, be safely tied if asepsis is observed. Antiseptic and absorbable animal ligatures are the safest, and, if properly prepared, are never in themselves the cause of hæmorrhage. An artery which has been merely bruised by an injury, *e.g.* gun-shot, may give way from sloughing of its coats.

The frequency with which secondary bleeding occurs in some vessels as compared with others depends, not upon their relative calibre, but upon the thickness of their walls. Thus, the subclavian vessels are much thinner than are the external iliacs. Proximity to the heart must also be regarded as a predisposing cause of secondary hæmorrhage.

Phenomena of secondary hæmorrhage.—As a rule secondary hæmorrhage begins gradually, but by no means always so. There is more or less profuse oozing, the blood staining and coming through the dressings. Ceasing for a time, the oozing soon recurs more profusely, until, finally, the rent in the artery is suddenly enlarged, and great and often fatal bleeding results.

The bleeding usually comes from the distal side, partly because the internal coagulum is smaller, and the processes concerned in obliteration less extensive, and partly because this portion of the vessel has been deprived of its blood by the ligature occluding the vasa vasorum, and hence its vitality has been impaired.

Treatment—Preventive.—The occurrence of this serious accident must be guarded against by avoiding suppuration, and those causes upon which its occurrence has been shown to depend.

Perfect asepsis, careful operating, and the use of suitable and properly prepared ligatures, with sufficient physical rest, will scarcely ever be followed by secondary hæmorrhage.

Curative.—If secondary hæmorrhage should occur, the treatment must depend in some measure upon the situation of the vessel, and upon whether it is from an open wound, *e.g.* a stump, or from a vessel ligatured in its continuity. There is, however, one important rule which should never be departed from:—*Whenever*

secondary hæmorrhage has occurred—whether it is still going on or not—prompt and immediate action must be taken to deal with the vessel. Unless this rule be always acted upon, the patient is in a most dangerous position, for the bleeding, although slight at first and having perhaps stopped, may suddenly burst out and terminate fatally. A second rule is:—*Always tie at the bleeding spot when practicable.*

If there is but very slight oozing, it may be deemed safe to apply firm and equable pressure over the part, and below and above it; but the patient must be watched carefully by an assistant in case the bleeding becomes profuse. If after applying pressure the oozing continues, delay is no longer admissible—the artery must be at once secured.

Method of treatment in an open wound.—In the case of secondary hæmorrhage in an open wound (as distinguished from ligature in continuity), the sutures must be removed, the wound cleansed, and the bleeding vessel sought for. A tourniquet should be applied, and may be gently loosened when the wound has been cleaned, in order that the bleeding may indicate the position of the vessel or vessels.

The state of the vessel may be found to be so bad that it will not hold a ligature; it then becomes necessary to clean it for some little distance until a part is reached suitable for the purpose. The operation is sometimes by no means easy, either on account of the situation of the artery, or from the sloughy and rotten state of the wound—indeed, it may be impossible to ligature the vessel *in situ.* Under such circumstances, ligature in the continuity must be performed; this, however, is a serious proceeding, and is to be avoided if possible; it may not arrest the bleeding, since blood may be conveyed to the open artery by collateral channels, and, on the other hand, it may so interfere with the circulation that gangrene ensues.

If it be found impossible to secure the bleeding spot, the vessel being small and the tissues in a rotten condition, application of the cautery may be advisable; yet this again may result in further bleeding when the sloughs separate.

Even when the bleeding has been arrested by ligature it may recur; in such a case, if it is at all serious, amputation is the best treatment.

Method of procedure in ligature in continuity.—If the bleeding comes from a deeply-seated vessel, such as the subclavian, direct pressure is the only available means of attempting to check it—other means being impossible.

If the bleeding is from an accessible artery, but is only slight in

amount, firm pressure and bandaging may permanently arrest it. Should this fail, the wound must be opened up, and the vessel sought for and ligatured, being cleaned for a short distance if the coats are too rotten to hold the ligature. The distal end must always be secured, since the bleeding commonly comes from it. If the state of the wound and vessel is such that ligature *in situ* is hopeless, the artery must be tied in its continuity, but this is to be avoided if possible—(1) Because the bleeding may continue through collateral trunks; (2) because it often comes from the distal end; (3) because obliteration of the vessel at two points entails a serious risk of gangrene. In many cases it would be much wiser to open up the original wound, more freely expose the artery and ligature in a healthy part. Should hæmorrhage recur after ligature, or should it be deemed unwise from the state of the limb to ligature in continuity, amputation offers the safest remedy, especially in the lower limb.

TRANSFUSION OF BLOOD—INTRAVENOUS INJECTION OF SALINE SOLUTION

Until recently, transfusion of pure or defibrinated blood was employed in cases of severe bleeding, and in certain cachectic states dependent on deterioration in the quantity or quality of the blood. It has, however, been shown that, whatever theoretical considerations might on physiological grounds be urged in favour of this practice, the dangers attending it are so great, and the advantages claimed—as compared with those obtained from intravenous injection of saline solution—so inappreciable, that transfusion of blood may be considered an obsolete therapeutic procedure.

Death from hæmorrhage is due to failure of the heart's action in consequence of the sudden withdrawal of fluid from the circulation. The fall of blood-pressure is great and sudden, the heart acts at a mechanical disadvantage, and the circulatory mechanicism is brought to a standstill.

If the amount of blood lost can be replaced by normal saline solution, or even by water, the intravascular pressure is maintained, and the patient's life may be saved even in the most desperate cases. On theoretical grounds it would at first sight appear obvious that blood should, if possible, be replaced by blood; but it is found on critical examination that, apart from the dangers attending transfusion, the blood so transfused quickly undergoes changes, depriving it of its normal vital properties.

Soon after transfusion, the red blood cells disintegrate, and hence are no longer available as oxygen carriers; this disintegration appears to be accelerated by the addition of sodium phosphate, which has, on theoretical grounds, been mixed with defibrinated blood used for transfusion.

When the red cells break up, they may do so in the general circulation instead of, as is usual, in the spleen and bone marrow; should this occur, fever and hæmoglobinuria will result. The white corpuscles also break up, and may lead to widespread thrombosis, especially affecting the pulmonary and portal capillaries. This destruction of the red and white corpuscles and the accompanying changes in the plasma, not only render the blood useless as blood, by depriving it of its respiratory and nutritive value, but expose the patient to the serious dangers already referred to.

The intravenous injection of saline solution is free from danger if due care be taken to exclude air; it is, moreover, easy of performance, and needs no elaborate apparatus.

Its beneficial effects are due to the maintenance of the blood pressure, which permits of the proper action of the circulatory mechanism being sustained. Immediately after the injection, the heart beat is strengthened and accelerated; and hence the blood, although diminished in quantity, is more rapidly circulated through the body.

The water employed should, if time permit, be first boiled and then allowed to cool, and used at a temperature of 100° F. Water may be used alone, but the addition of one drachm of sodium chloride to the pint increases the density, making it more nearly that of the blood. The fluid is readily introduced into the median basilic vein by gravity alone, its rate of flow being regulated by the height of the column of fluid; about one pint may be introduced every ten minutes. The quantity used must be proportional to the amount of blood presumably lost, and must be regulated by the effect upon the circulation as evidenced by the pulse.

In some cases a large quantity—as much as six pints—may be required. The simplest apparatus consists of a small canula for introduction into the vein, connected by means of a piece of clean tubing with a funnel or small irrigator—care being taken that no air is present in the tube or canula; by raising or lowering the funnel, the rate of flow of the fluid can be accelerated or diminished at pleasure. However hopeless a case of hæmorrhage may appear, intravenous injection should always be performed. Warm saline solution injected into the rectum is rapidly absorbed, and should be employed if for any reason intravenous injection cannot be done.

CHAPTER VI

Injuries of Bones

CONTUSION—SEPARATION OF THE PERIOSTEUM

A bone may be simply contused by a blow, or a wound may separate the periosteum. Simple contusion causes considerable pain and effusion of blood beneath the periosteum and into the soft structures. Traumatic periostitis may result, and in some cases acute necrosis is caused by micro-organisms finding their way from the ruptured blood-vessels into or beneath the periosteum. Tubercular disease and periosteal sarcoma are sometimes traceable to injury.

A simple contusion needs nothing more than rest and the application of cold. Should periostitis result it must be treated as directed in the chapter on Diseases of Bones, vol. iii.

If the periosteum has been stripped from the bone, necrosis of the denuded portion may ensue, but in the majority of cases, provided asepsis be secured, no ill results follow. Necrosis is most likely to occur in the case of the skull, for in this situation the reparative power of the periosteum is slight.

FRACTURES

Varieties.—A fracture is a "sudden and more or less violent solution of the continuity of a bone." Usually the whole thickness of the bone is involved (**complete fracture**), but in some cases, *e.g.* punctured and greenstick fractures, this may not be the case (**incomplete or partial**).

A **simple** fracture is one in which there is no wound leading to the seat of fracture; when such a wound exists the fracture is said

to be **compound** (p. 108). Some fractures, *e.g.* of the lower jaw, nasal bones, middle and anterior fossæ of the skull, are from their anatomical position usually compound.

A fracture is said to be **complicated** when there is some serious local injury in association with it; thus it may be complicated by dislocation of the bone, rupture of a large vessel or nerve, by extension into the joint, or by wound of a viscus. Some fractures are necessarily complicated by involvement of the joint (p. 112).

A **comminuted** fracture is one in which the bone at the seat of fracture is smashed into several pieces, but if fracture has occurred in two places the injury is said to be **multiple.** In **impacted** fracture the fragments are welded together owing to one having been driven into the other; impaction frequently leads to much fissuring or to comminution.

Separation of an epiphysis is a form of fracture which will be considered separately (see p. 114).

Fractures are also designated according to the direction of the break as transverse, oblique, longitudinal, spiral, fissured, stellate, or T-shaped; and in the case of the skull the fracture may be punctured or depressed. Pure transverse fractures are rare, the line being almost always oblique, although the obliquity may be very slight; hence the term transverse must be taken to imply only slight obliquity rather than its exact meaning. Transverse fractures are usually produced by direct violence or muscular action; the displacement is reduced to a minimum and union occurs quickly with but little deformity. Oblique fractures are usually due to indirect violence, the obliquity being more marked the more nearly the violence is applied in the direct axis of the bone.

Causes.—Fractures are traumatic or spontaneous. Spontaneous or pathological fractures are also in part traumatic, for although the bone is weakened by disease the actual fracture is caused by some slight degree of violence. Certain constitutional conditions induce peculiar brittleness of the bones (*fragilitas ossium*), and consequently multiple fractures from very slight violence are common. The pathological states especially worthy of note in this respect are tabes dorsalis, general paralysis, inherited syphilis, scurvy, rickets, osteomalacia, and malignant disease. Senile atrophy also leads to considerable brittleness of the bones.

Predisposing causes.—Active adult life is the period during which fracture most usually occurs; in the young the soft bones incline to bend rather than break and greenstick fracture results. Separation of the epiphysis is usually met with in young children and

never after the twentieth year. In old age the bones are more brittle and are therefore more readily broken; but old people, from their habits of life, are less exposed to injury, and consequently fractures on the whole are with them uncommon, although Colles's fracture and intracapsular fracture of the femoral neck are essentially injuries of advanced life. In old age fracture is more common in the female sex. Sex and occupation obviously influence the frequency of the occurrence of fracture proportionally to the risk of injury. The special liability of any bone to fracture depends upon its shape, position, and function as regards the distribution of force applied to the region of the body in which it lies; thus the clavicle, transmitting as it does all force applied to the arm or shoulder, and acting as the support of the shoulder girdle, is peculiarly liable to fracture, and is more often broken than any other bone in the body. Long bones are more frequently broken than are others, and those of the upper rather than those of the lower limb. The patella, from its position and its situation in the strong extensor tendon, is frequently broken by muscular action. The precise point of fracture of any bone depends upon the method of production of the injury.

Immediate causes.—Fracture may be due to direct or indirect violence or to muscular action. The degree of violence necessary to break a bone varies according to its solidity and strength and the direction of impact.

Direct violence breaks the bone at the point struck and may cause more or less comminution. The line of fracture is more transverse than oblique, and in the forearm and leg the two bones are generally broken at the same level. Direct violence causes considerable bruising and extravasation at the seat of injury.

Indirect violence is the most common cause of fracture, the bone giving way at the weakest part. The resulting fracture is oblique, the obliquity being more marked if the violence has been applied in the direct axis of the limb. If both bones of the leg are broken by indirect violence the fibula gives way higher up than the tibia. The damage inflicted on the soft parts at the seat of fracture is reduced to a minimum, and is due not to the fracturing force, but to the movement of the fragments.

Muscular action is much more likely to cause fracture if the bone be weakened by disease or atrophic changes.

The patella is the common seat of this injury, but the olecranon, great tuberosity of the humerus, and long bones may also be broken by muscular action

The ribs are occasionally fractured by the violent muscular contractions of tetanus or parturition.

Fractures by muscular action are transverse in direction and the soft structures are not damaged.

Gun-shot fractures are described under Gun-shot Injuries (p. 39).

The diagnosis of fracture.—Before making any examination of the injured part in a case of supposed fracture, the surgeon should ascertain as nearly as possible the precise details of the accident, from which he may be able to form a fairly accurate opinion as to the seat and extent of the damage inflicted. The exposure and examination of the part must be conducted with the utmost gentleness, not only on ordinary humanitarian grounds, but in order that the damage may not be increased and the fracture possibly rendered compound. If the case is not seen until some time after the accident, and there is much swelling and bruising of the limb obscuring the precise nature of the injury, the part should be temporarily put up in an easy position calculated to relax the muscles, and ice-bags should be applied for a few days, when a proper examination can be undertaken.

Some of the signs of fracture are diagnostic in themselves, while others are not necessarily accompanied by, or met with in cases of, fracture; thus pain, bruising, and impairment of the utility of the limb may similarly be present in cases of dislocation or simple contusion.

The essential signs of fracture are deformity, increased mobility, and crepitus; but each and all of these may be absent, as in fractures of the skull.

Deformity.—Accurate measurements must be taken of the sound and injured limb placed in the same position.

The deformity in cases of fracture is due in the main to the displacement of the fragments by muscular action, and hence varies with the exact seat of fracture; but it is also influenced by the weight of the limb and by the direction of the fracturing force and the obliquity or otherwise of the line of fracture. It is important to make out as far as possible the precise nature of the deformity, so that the manipulations necessary to correct and set the fracture may be conducted with the least possible amount of injury to the soft parts. Shortening is the rule, and is due to the over-riding of the fragments (Fig. 25, p. 102); lengthening is sometimes present, as in the wide separation of the fragments in transverse fracture of the patella. The more oblique the line of fracture the more

marked is the longitudinal displacement and overriding. In impacted fractures the amount of shortening may be very slight.

Lateral, angular, and rotatory displacement may be due to muscular action, or to the weight of the limb; thus, in fracture of the shaft of the femur, the upper fragment is drawn forwards and rotated outwards by the ilio-psoas and external rotators, the leg and lower fragment being everted by the weight of the limb causing it to assume the natural position of rest. In simple linear fractures and in those on which the periosteal covering remains intact—as is frequently the case in children—deformity is absent or ill-marked.

Increased mobility is present, except in cases of incomplete or impacted fractures, or in fractures of fixed bones, *e.g.* the skull. In fractures implicating joints it may be very difficult to make out this sign as the mobility may be masked by the normal movements at the articulation. If the displacement of the fragments be reduced they will not retain their position without support, the muscles, if not antagonised, immediately reproducing the deformity.

Crepitus can, in most cases, be both felt and heard; but it is absent in incomplete, linear, and impacted fractures, and may be very difficult of recognition in deeply-seated bones. It may also be difficult or impossible to obtain crepitus where there is want of apposition of the fragments, either in consequence of great over-riding or of wide separation, as in fractured patella, or when they are separated by the intervention of a piece of muscle or tendon.

Crepitus is obtained by firmly grasping the fragments, and by moderate traction drawing the ends into apposition, when they are gently moved on each other. Bone crepitus is peculiar in its characters, being sharp and grating, and is thus easily diagnosed from crepitus of other origin. Lymph effused into a tendon sheath or a joint cavity produces a peculiar dull feeling of crepitus which can hardly be mistaken for true crepitus if due care be taken. Pericardial and pleural effusion also occasion fremitus, which might possibly be mistaken for the crepitus of a broken rib.

Surgical emphysema, and the peculiar crepitus met with in blood-clot when pressed upon, can hardly give rise to difficulty. Cartilage crepitus is dull and lower pitched in tone than true bone crepitus, and conveys a crackling sensation to the touch.

The **non-essential signs of fracture** are—pain, swelling, bruising, and impairment of the utility of the limb.

Pain is of a smart pricking character, is much increased by movement and muscular spasm, and is due to the irritation of the sharp ends of the fragments. Should these lie close to a nerve, the

pain may be very severe. *Swelling and bruising* are most marked in cases of fracture by direct violence, especially if an important vessel has been wounded. The swelling increases during the first few hours, and is sometimes extreme, so that blebs form on the surface and gangrene is threatened. In such cases the examination of the limb must be postponed until the swelling has been subdued by rest and the ice-bag.

Impairment or loss of function is partly voluntary in consequence of the pain, but is chiefly due to the fact that the muscles are unable to work properly, as the leverage is lost. In impacted and incomplete fractures, and in some other cases, the impairment of function is but little marked; thus a patient may be able to walk with a fractured fibula, or with impaction of the femoral neck.

Complications and later results of fracture.—Certain general and local conditions of more or less gravity may arise as the direct result of fracture, and others may be due to associated injury. The latter will be more definitely dealt with under complicated fracture (p. 112). Among the general complications hypostatic pneumonia, delirium tremens, and traumatic fever may occur as in any other injury. Hypostatic pneumonia is very liable to occur in old and enfeebled patients if they are long confined in the dorsal position, and hence every care should be taken that the fracture is immobilised in such a manner as to render such confinement unnecessary.

Simple traumatic fever is usually very slight and transient, but is more severe if the soft structures have been much damaged and there is much extravasation. Fever arising in connection with compound fracture may be due to septic absorption.

Fat embolism is probably more common in cases of fracture than is generally supposed, since it is only in severe cases that its occurrence gives rise to symptoms, and these are always of an equivocal nature. Fat embolism is not by any means peculiar to cases of fracture, but may occur in any condition in which fluid fat can find its way into the vessels, *e.g.* contusion of a fatty liver. The entrance of fat is favoured by tension, and hence embolism is most likely to occur in severe comminution and smashing of a bone as the result of direct violence. The fatty emboli lodge chiefly in the lung, but may also be found in the brain and other viscera, and it is said that fat globules may be excreted with the urine.

The entrance of fat does not appear to take place simultaneously with the fracture, but some time during the first twenty-four hours; hence the symptoms make their appearance when shock has passed off—if any was present.

In severe and fatal cases the main symptoms are dyspnœa, frequency of respiration, cyanosis, irregular action of the heart, and gradually deepening coma, terminating in death. Treatment seems to be of no avail. The intravenous injection of ether with a view to dissolving the fat has been suggested, but is not to be recommended.

The dyspnœa and respiratory trouble has appeared to some to indicate the employment of artificial respiration; but as there is no impediment to the entrance of air into the lung—the dyspnœa being entirely due to interference with the pulmonary circulation—it is difficult to see what benefit could accrue from such treatment.

Local complications are due chiefly to bruising and laceration of the soft structures, accompanied by extravasation, serous exudation, and impairment of the circulation.

Vesicles and bullæ, often containing bloody serum, may result as the direct consequence of bruising, or at a later date from galling by ill-applied splints and bandages, or from inflammation or gangrene. If bullæ form, the fluid should be evacuated by puncture and the part dusted with boracic acid and protected; but the epidermis should not be removed, since it affords protection to the skin beneath.

Extravasation may be very great, especially in fractures due to severe direct violence. The degree of swelling and extent of bruising is proportional to the effusion of blood. The application of cold promotes absorption. Suppuration follows but rarely; should it do so, the abscess must be opened under strict antiseptic precautions, as the fracture will thereby be rendered compound.

Œdema may be caused by improperly applied and over-tight bandages, especially when the main venous channels are compressed. Thrombosis of the veins at the seat of fracture is not uncommon, and may cause a certain amount of œdema, which may persist for some time after union is complete; it must be treated by cold douching and gentle massage.

Gangrene may result from tight bandaging, especially if a bandage has been applied beneath the splints—a practice to be strongly condemned. When any retentive apparatus has been once applied, the exposed part of the limb beyond the seat of fracture, *e.g.* fingers or toes, should be daily examined for a few days, in order that the efficiency of the circulation may be tested; otherwise swelling may set in beneath the apparatus and cause death of the limb. Gangrene may also be due to reactionary inflammation, or to damage or compression of important arteries or veins. If gangrene is threatened,

all splints, etc., should be removed, and every effort made to avert the calamity; but should this prove impossible, amputation must be performed.

In the case of comminuted fractures, detached *fragments may necrose* and excite suppuration.

Paralysis of nerves may result from rupture at the time of fracture, from their subsequent involvement in callus, or, in the case of the upper extremity, from the pressure of a crutch. Severe contusion of a nerve may give rise to symptoms similar to those due to section. When a nerve is supposed to have been damaged in a case of simple fracture it should not be cut down upon, but should be left to see if any repair follows, as will be the case if it has only been contused; later on it must be sutured if it has been torn. The treatment necessarily varies with the cause. If a nerve trunk is involved in the mass of callus, its functions will probably be restored as the latter is absorbed; should this not occur, or should the condition of the nerve urgently demand treatment, it must be cut down upon and freed.

The complications met with in special fractures will be discussed in subsequent chapters.

Prognosis in fracture.—Except in the case of fixed bones, there is always some slight degree of permanent shortening, since it is practically impossible to obtain absolute accuracy of apposition of the fragments. Other things being equal, the amount of shortening will be greater if the bone is extensively comminuted, as in gun-shot injuries. Greenstick, incomplete, and linear fractures do not give rise to any appreciable shortening. In the young, a fracture, not implicating the epiphysary line, does not cause permanent shortening, since growth is still in progress.

Angular, longitudinal, or rotatory displacement will be permanent unless steps have been taken to remedy the false position at the time of putting up the fracture. Fracture of the end of a bone usually heals more readily and leaves less permanent deformity than does similar injury of the shaft; but if the joint has been implicated, stiffness or adhesions may result, especially if the employment of passive motion has been long delayed.

Pain, swelling, and weakness of the limb may last for many months.

General principles of treatment—**Temporary means** must be adopted while the permanent appliances are being obtained. In cases of simple fracture, temporary splints may be readily improvised, and should be lightly but efficiently applied to prevent movement of the fragments during the removal of the patient. The clothes need not be removed, but every care should be taken

that the sharp ends of the fragments do not penetrate the skin and hence render the injury compound. If the fracture is compound the clothes must be immediately slit up so as to expose the wound, and temporary means adopted to arrest any bleeding (see p. 76).

Permanent means.—When the nature of the injury has been ascertained by gentle and careful examination, the fracture should be set without delay. As a rule an anæsthetic should be avoided, but in some cases muscular spasm and pain are so great that the patient involuntarily prevents the necessary manipulations, and either reduction must be postponed for a time until the spasm is less or chloroform must be given; in the latter case great care must be taken that the movements of the patient, as he is going under the anæsthetic, do not increase the damage to the soft parts. If reposition of the fragments is postponed for a few hours, the muscles which are at first partly relaxed and do not therefore offer any strong resistance, contract strongly and are with difficulty overcome; moreover, there is but little swelling in the first few hours.

If the fracture is not seen until some time after the accident, and there is considerable swelling—perhaps with signs of impeded circulation or inflammation—the limb should be placed in the easiest position and kept at rest by light splints, sand-bags, or extension, and an ice-bag should be continuously employed. When the swelling has in a great measure subsided, a favourable opportunity should be taken to set the fracture. The measurements of the injured limb must be compared with those of the opposite side, and the various bony and anatomical landmarks must be brought into their proper mutual relations.

The movements necessary to bring about the most accurate apposition of the fragments necessarily depend on the nature of the fracture and consequent deformity; but whatever are necessary must be conducted with gentleness and deliberation, and under no circumstances must they be hurried, jerky, or unduly forcible, otherwise the muscular spasm will be increased, or pain or inflammation will result. If muscular resistance is so great that the fracture cannot be properly set, even when the limb is held in such a position, *e.g.* bent at the knee in fractures of the leg, that the muscles are relaxed, an anæsthetic may be given.

In fractures of the long bones, extension and counter-extension will usually bring the ends of the fragments into apposition. No pressure must be made on the actual seat of fracture. Slight lateral or rotatory movements are sometimes necessary to free the ends of the fragments from the structures among which they lie.

As a rule no attempt should be made to separate impacted fragments, unless the impaction is accompanied by much deformity.

The application of splints, etc.—The fracture being set, some apparatus must be applied with the view of maintaining the fragments in place and securing rest during repair. For this purpose splints or some form of immovable appliance must be employed, the preference being always given to the simplest form which is at the same time effective. Complicated splints are seldom necessary and should be avoided. Wooden splints may be readily made from a piece of deal board, and are very light; perforated tin or zinc, or splints of iron-gauze are sometimes used but have the disadvantage of being heavy and clumsy. Gooch's splinting is very useful as, being movable in one direction, it can be made to fit the rounded contour of a limb; it consists of narrow pieces of wood glued to leather or oil-cloth. Felt, leather, mill-board, and gutta-percha are easily worked, and make excellent light supports, but are not sufficiently firm for fractures of large bones. In making a gutta-percha splint, the required shape is cut in paper and the gutta-percha cut rather larger than the pattern since it shrinks in cooling; the gutta-percha wrapped in calico is next placed in hot water, and when sufficiently plastic is moulded to the part, removed, allowed to get quite cold, and then trimmed and lined with chamois leather.

Whatever form of splint is used, it must be long enough to fix both joints with which the broken bone is related, provided that movement in either will cause movement of the fragments. When the fibula only is broken the tibia acts as a very efficient support, and hence the knee-joint need not be immobilised; and in fracture of the forearm the position in which it is placed renders fixation of the elbow unnecessary. The splints should be a little broader than the limb, and are never to be used to exert direct pressure on the fragments with the view of *forcing* them into position, their object being merely to ensure rest, and as far as possible give support to the limb, so that its weight may not cause displacement of the fragments during repair.

Whatever apparatus is used must be well and evenly padded, especially in the neighbourhood of bony prominences; by this means surface inequalities are filled up and irritation of the skin by pressure is avoided.

When the limb has been carefully washed, dried, and powdered, the padded splints are applied direct without any bandage beneath, for if there be one and swelling should come on, there is great

danger of gangrene. The splints are kept in position by well-applied bandaging, the actual seat of fracture being left uncovered if the state of the soft parts, *e.g.* extensive bruising, renders it expedient to keep it under observation.

In the practice of many, splints have been largely superseded by the use of bandages of plaster of Paris, starch, liquid glass, dextrin, ordinary flour paste, glue, paraffin, or gum and chalk, the first three being most in favour. To give additional strength to such an immobile apparatus, strips of mill-board or tin may be placed in the axis of the limb between the layers of the bandage. In many cases the use of plaster of Paris bandages is preferable to any form of wooden splint, and is certainly more convenient, but discrimination in its use is necessary. If the soft parts are contused and there is much swelling, with inflammation and gangrene as possibilities, the proper practice is to use light splints until all danger from these causes has passed away. If there is considerable swelling, the use of plaster may be disastrous, for the swelling may increase beneath the unyielding casing and gangrene from pressure result; or, if the swelling subsides, the casing becomes loose and must be reapplied, necessitating additional movement of the fragments.

Mode of application of plaster of Paris bandages.—The limb must be washed, dried, and powdered, and covered by a flannel bandage, so that the plaster is kept from direct contact with the skin. Bandages of crinoline-muslin, which have been freely powdered with the best fresh modelling plaster and placed in water for a few minutes, are now applied so as to completely fix the part, two or three layers being usually sufficient to ensure the requisite rigidity when dry. The bandages must be lightly applied, and should not be tightened or reversed. The plaster sets in a few minutes, and is quite dry and hard in an hour or more. When the casing has hardened a portion may be cut away opposite any wound or bruise, if it is considered necessary to keep it under observation.

Plaster splints introduced by Croft have some advantages over a complete casing and are described at p. 188.

The starch bandage is very light, and when the skin is tender, as in old people and children, may be used with advantage. It has the disadvantage of taking many hours to dry, and requiring removal and trimming when completely set. If greater strength is required than simple starch bandages will confer, strips of millboard should be placed between the layers of the bandage.

The limb is evenly wrapped in a smooth sheet of cotton wadding, and strips of millboard, previously rendered pliant by immersion in

boiling water, are accurately moulded to the limb in the most suitable positions. Ordinary bandages are then applied and warm starch is rubbed in as each turn is taken. The turns may be drawn tight as they tend to loosen. The limb must be placed between hot bottles to hasten drying which may take twenty-four hours or longer. When it is complete the casing must be cut up along the front, trimmed to fit accurately, and reapplied and held in position by a bandage.

Paste, glue, gum and chalk, or similar substances may be used in place of starch.

Wiring the fragments has been prominently brought forward recently, but while advocating this method for the treatment of cases in which proper apposition cannot be obtained by other means, most surgeons would be disinclined to adopt it as a routine practice. When the fragments have been fully exposed and placed in accurate apposition, they are united by silver or copper wire, or by means of steel pegs or screws. Under proper antiseptic precautions such an operation cannot be regarded as serious and should certainly be undertaken in difficult cases.

When a broken bone has been immobilised by one or other of the methods mentioned, the limb must be placed in the most easy position which is best calculated to relax the muscles acting on the fragments.

If the patient is confined to bed the mattress should be comfortable, but firm, and care must be taken to prevent the formation of bed-sores. The weight of the clothes may be taken off by a cradle. If plaster or other immovable apparatus has been employed, the patient may be allowed up on crutches in two or three days; this is of great importance in the aged and feeble who are so liable to hypostatic congestion.

So long as there are no symptoms demanding an examination of a fractured limb it should be left untouched, the surgeon having satisfied himself that he has attained the best possible position for the fragments. Rest is the great desideratum. At the same time, it is most important that stiffness should be obviated by daily massage and gentle passive movement in cases where prolonged fixation is likely to lead to such results, *e.g.* fractures about joints. When the ordinary time required for complete union has elapsed, the apparatus should be removed and the seat of the fracture examined with the view of ascertaining the strength and efficiency of the bond of union. Wasting and atrophy of the muscles, œdema, stiffness of the joints, etc., should be treated by douching,

massage, and passive motion, the parts quickly recovering under ordinary circumstances. The patient must not be allowed free use of the limb until union is quite firm, otherwise re-fracture may result.

THE REPAIR OF FRACTURES

In a case of recent fracture the ends of the fragments are surrounded by blood-clot, which is present in the medullary canal, beneath the periosteum, and in the surrounding soft structures, these being, especially in fractures by direct violence, more or less lacerated and contused.

The periosteum is torn across in part or all of its circumference, but is not usually separated from the bone for any distance. In the case of fissured fractures, or those of young bones, the periosteum may remain intact, thus serving to maintain the fragments in apposition. During the first few days there may be some traumatic inflammation with considerable exudation and swelling, especially if the parts are much damaged. At the end of a week or ten days, during which time the blood-clot has become in great measure absorbed and the remainder decolorised, the fragments will be found embedded in soft vascular new tissue (*provisional callus*) derived from the periosteum, and also, in less amount, from the medulla and soft structures. The provisional callus within the medullary canal is known as "internal," that beneath the periosteum as "external."

FIG. 24.—A fracture united by callus. *a*, *b*, the compact layer of the bone; *c*, external callus (Follin).

The provisional callus is practically the same as the granulation tissue met with in wounds of soft parts, and is composed, at first at least, of leucocytes and newly-formed vessels; but after a short time this material is invaded and replaced by bone-forming cells or osteoblasts derived from the periosteum and medulla, the cells of which are alone capable of forming new bone. The callus is at first soft, but soon becomes more dense and fibrous or fibro-cartilaginous in structure, and ultimately ossifies. In man it very rarely undergoes development into cartilage before ossification, although this is not uncommon in animals and in young children; in fractures where there is much movement during repair, *e.g.* the ribs-fibro-cartilage is sometimes found.

In the process of ossification lime salts are laid down by the osteoblasts, and thus fine trabeculæ are formed, which gradually increase in solidity and density, and lie at right angles to the bone.

Provisional callus is by no means necessary to the process of repair, and when movement during treatment can be reduced to a minimum very little is thrown out; in linear fractures of the skull there is practically none, an additional reason for its absence in this situation being the poor osteogenetic power of the cranial periosteum. The amount of provisional callus, being proportional to the degree of irritation, is largest in children who are naturally restless under treatment, and in bones like the ribs or clavicle which cannot be kept at perfect rest. A complete ensheathing ring of callus is rarely found. In fractures with over-riding of the fragments, the callus unites the opposed surfaces (*intermediate callus*) and fills up any irregularities; the ends of the fragments are rounded off by absorption, and the medullary canal is closed by a thin plate of bone (Fig. 25).

FIG. 25.—Vicious union of the right femur. The fragments are united, with over-riding, by intermediary callus. (Westminster Hospital Museum, No. 27. Drawn by C. H. Freeman.)

The amount of callus may be excessive if there has been much inflammatory mischief excited and kept up by necrosis of fragments or any other causes.

When ossification begins in the provisional callus definitive or *permanent callus* is poured out between the ends of the bones which have undergone rarefaction through absorption of the bony lamellæ by osteoclasts. This callus undergoes the changes already described, and ultimately very dense bone is formed as the permanent means of union. This is denser and harder than normal bone.

In the forearm and leg, if both bones are broken, they may become united by bridges of callus (Fig. 26). In the leg this is of little importance, but in the forearm it prevents supination and pronation. In the case of fractures extending into joints, *e.g.* the elbow, the callus may, by filling up the normal articular depressions, cause considerable limitation of movement pending the time of its removal by absorption. Nerves, *e.g.* the musculo-spiral, may be implicated in callus and their function lost in consequence of degeneration through pressure.

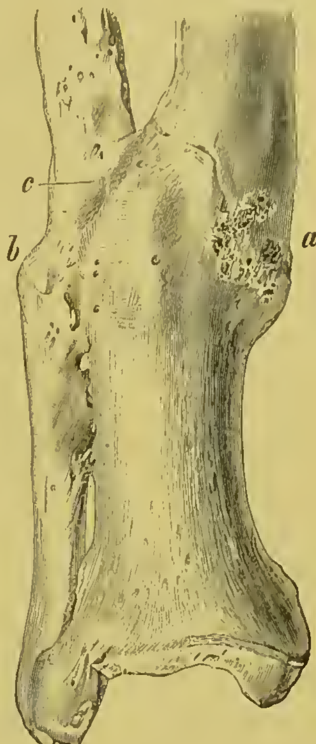


FIG. 26.—Union of a fracture o both bones of the leg; the two bones are connected by callus (Ziegler).

Union of a compound fracture occurs in the same way as in the simple injury. Granulations spring up from the bottom of the wound and gradually grow up to the surface as in a wound of the soft parts. Should suppuration occur, the process is more prolonged, dead fragments of bone are extruded unless they are removed by the surgeon, and the amount of callus is large.

The duration of the process of repair depends upon a variety of circumstances. As a rule union occurs rapidly in the young and healthy, but is delayed in the aged or diseased. It is more rapid in small than in long bones, in those of the upper than in those of the lower extremity, and in distal rather than proximal bones.

Provisional callus usually ossifies into spongy new bone in from three to ten weeks; but its final development into hard dense bone, and the absorption of the redundant portions may not be complete for a year or more.

The absorption of the internal provisional callus and re-establishment of the continuity of the medullary canal may take a very long time or never occur.

DEVIATIONS FROM THE NORMAL PROCESS OF REPAIR —NON-UNION, FIBROUS UNION, FALSE JOINT

Causes.—Under certain circumstances dependent on some constitutional condition of ill-health, or on some local peculiarity

of the fracture, union of the fragments may be delayed or arrested at any stage in the process.

General causes.—Non-union is more common in men than women in the proportion, it is stated, of 6 to 1. Constitutional disease predisposes to non-union, on account of the general failure of nutrition induced, rather than from the specific nature of the malady. Non-union is favoured by scurvy, rickets, syphilis, phthisis, the acute specific fevers, and the presence of malignant disease at the seat of fracture. Previous bad health from insufficient food, especially want of fresh meat and vegetables, or from non-hygienic conditions, is an important causative factor. The bones of the aged unite less readily than those of people in active adult life, partly because the nutrition and reparative powers are at a low ebb, and partly because the osteogenetic powers of the periosteum diminish with age.

Pregnancy and lactation are said (probably without sufficient reason) to predispose to non-union. In the case of compound fractures the occurrence of septic processes in the wound may result in non-union, not only owing to the local condition but by materially undermining the general health.

In most cases it must be confessed that no general cause can be assigned, the condition being dependent upon local causes merely.

Local causes.—Interference with the blood-supply of either fragment is an important element in the production of non-union. If the nutrient artery be torn across, or if one fragment has to depend for its nutrition on the periosteum alone, the main efforts at repair are seen in the better nourished fragment, and even these may be totally inadequate to effect it. In intracapsular fracture of the neck of the femur the blood supply to the upper fragment is very small, and this, combined with the usually advanced age of the patient and want of accurate apposition of the fragments, prevents union.

Wide separation of the fragments, as in the case of transverse fracture of the patella; their over-riding or the intervention of a piece of muscle or tendon between them; suppuration, or necrosis of fragments, may all result in non-union.

Want of rest during treatment and a faulty position of the fragments are the most potent of all causes. In cases of spontaneous fracture union may take a long time or not occur at all.

Varieties—Delayed union.—In some cases it will be found that a fracture is not consolidated at the usual time, although strong union eventually occurs.

Non-union is the condition in which repair has absolutely failed, although a little soft spongy callus may have formed but has been

subsequently absorbed. The fragments will be found atrophied, the medullary eanal closed, and thc ends rounded off by absorption and embedded in fibrous tissue.

Fig. 27.—Fracture of the patella united by ligamentous tissue, from a specimen in the Westminster Hospital Museum, No. 100 (Holmes, *System of Surgery*).

Fibrous union (Figs. 27, 28) is by far the most usual deviation from normal repair, and is all we ean hope for in eertain fraetures, *e.g.* transverse fracture of the patella. The uniting bond of fibrous tissue varies in density, strength, and length; sometimes it is so intimate and strong that but little, if any, real ineonvenience results; in other eases the fragments may be separated by a long distance, and the part be proportionately useless.

Fig. 28.—Fibrous union after fracture of the fibula (Ziegler). *a*, lower fragment; *b*, upper fragment; *c*, fibrous tissue.

False joint (Fig. 29, p. 106) is only met with if movement has been considerable during treatment, either in consequence of imperfection in the appliances used or of natural restlessness on the part of the patient.

The ends of the fragments are smoothly adapted to one another; they are covered with fibrous tissue, or — very rarely — with an imperfect layer of cartilage, and are united by a fibrous eapsule lined with an imperfect synovial membrane. The false joint is of the diarthrodial variety.

Treatment.—The possibility of the oeeurrenee of non-union and the eireumstanees favouring it should always be borne in mind in cases of fracture, and every effort must be made to prevent it.

Those of enfeebled health ought not to be confined to bed or the house longer than is absolutely neccssary, but should spend plenty of time in the fresh air, the fraeture being immobilised in plaster or some immovable applianee. In a ease of

simple delayed union, tonics, good food, and fresh air, combined with complete rest in an immovable casing, will usually prove successful; should these means fail, the fragments may be forcibly rubbed against each other, under an anæsthetic, so that a certain degree of inflammation is excited, after which complete rest should be enforced for a time varying according to the nature and position of the fracture. The application of blisters or the actual cautery over the seat of fracture may also be of service. Quite recently thyroid extract has been advocated and tried with success, and may be safely employed, before operation is undertaken, if other means fail.

FIG. 29.—False joint after fracture, showing a large and loose synovial capsule containing numerous false cartilages (Holmes, *System of Surgery*).

Should all such attempts at promoting union fail, or should they be inapplicable on account of the time which has elapsed since the fracture, some radical operative measure is required.

In arriving at a decision as to the advisability of operating, and the prospect of success, it is necessary to determine, as far as may be, the actual cause of the condition, the degree of utility of the limb in its present state, and the state of the ends of the fragments. If the inconvenience is slight, and the probabilities of success small, operation is not advisable, and the surgeon must do the best he can by devising some form of apparatus permitting movement at the joints, but limiting it, as far as possible, between the fragments. If cure is to be attempted, operation is the readiest and surest means of attaining that result. No surgeon would, in view of the great safety of operations under strict antiseptic precautions, attempt to cause union by the introduction of needles, or by subcutaneous section of the fibrous bands; still less would it be advisable to inject iodine or other irritating drugs as was formerly done with a view to stimulating the reparative process into activity.

Dieffenbach's operation consists in exposing and freshening the

ends of the fragments, and introducing ivory pegs into holes drilled for the purpose. The pegs may be made to unite the fragments, though this is not necessary; it has, however, the advantage of ensuring more complete rest. They may be safely left, and the wound closed; they will gradually undergo absorption. Steel screws and pegs may also be used.

Resection, and fixing the ends of the fragments by means of wire sutures, by introducing cylindrical pieces of ivory into the medullary canal, or by enclosing the fragments in an ivory ferrule, is the most certain operative procedure. The operation is thus performed:—

The fragments are exposed and cleared from the soft parts for a short distance; they are then freshened by removal of the ends. The plane of section should be oblique, so that larger areas of bony surface are brought into contact. A bone ferrule may now be placed over the end of one fragment, and the other forced into it; or, if a medullary plug is used, it is placed in position in one fragment, like a cork in a bottle, and then forced into the other. If wire is used, holes must first be drilled, and pure silver wire is then introduced and hammered down. Care must be taken that the periosteum is not stripped from the ends of the fragments. The wound having been dressed with strict antiseptic precautions, should be closed, and the limb put up in an apparatus calculated to maintain perfect rest.

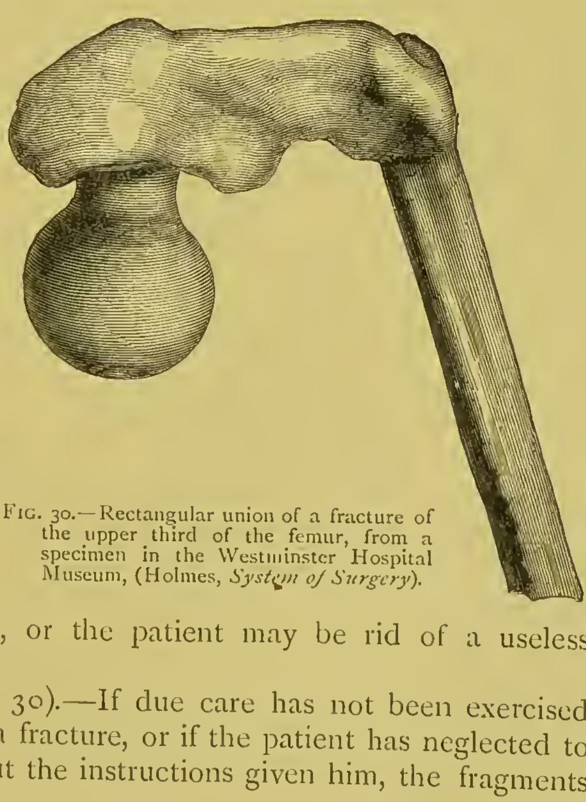


Fig. 30.—Rectangular union of a fracture of the upper third of the femur, from a specimen in the Westminster Hospital Museum, (Holmes, *System of Surgery*).

It often happens that in spite of all treatment, operative or otherwise, repair cannot be induced; under such circumstances an apparatus must be devised to reduce the inconvenience to a minimum, or the patient may be rid of a useless limb by amputation.

Vicious union (Fig. 30).—If due care has not been exercised during the treatment of a fracture, or if the patient has neglected to rest the limb or carry out the instructions given him, the fragments

may unite in a faulty position. Union may occur in the position of primary displacement, or the fragments may assume a fresh position during treatment. The degree of deformity varies within wide limits, from a slight error in the axis of the limb to such a degree of malposition that it is useless. In the forearm much trouble may result from union of the bones by a bridge of callus, whereby all movements of pronation or supination are lost.

Treatment.—In deciding as to the advisability of correcting the deformity by operative treatment, the surgeon must take into account the age of the patient, his general health, and the amount of inconvenience occasioned.

Refracture can only be accomplished within a few weeks from the date of the injury, when the callus is soft and can be broken by a reasonable amount of force. Anæsthesia is necessary, but the cumbrous machines which have been devised for refracturing bones are not only needless, but may do much harm, the surgeon's unaided efforts being quite sufficient. Care must be taken that no damage be inflicted on the soft structures by the employment of great and unjustifiable violence; unless refracture can be accomplished short of this it should not be attempted, and some operation must be undertaken. There is practically no risk of the bone breaking at the wrong place (provided the original injury is recent), since the callus is the weakest part. When refracture has been accomplished the case must be treated as one of recent fracture, due care being taken to avoid those causes which lead to vicious union.

Resection.—If refracture be impracticable, or its attempt not justifiable owing to the time which has elapsed since the injury, resection may be performed provided the patient's health is good. In performing this operation a free incision should be made, and the seat of fracture fully exposed. This is, under antiseptics, quite safe and preferable in most cases to subcutaneous osteotomy, as it enables the surgeon to avoid important structures, and see clearly what he is about. When the bone has been divided by the saw and chisel the limb is placed in the proper position, and is kept immobolised sufficiently long to ensure firm union. The wound in the soft structures may be left untouched for ten days, or even longer.

COMPOUND FRACTURE

When the seat of a fracture communicates with the air by means of a wound, the injury is said to be compound. A primary

compound fracture is one which is rendered compound at the time of the injury; the **secondary** form is due to subsequent exposure of the fragment by sloughing of the soft parts.

Primary compound fracture may be produced by the fracturing force lacerating the soft structures, or by the end of one of the fragments (usually the upper) penetrating the tissues, either in consequence of the indirect nature of the force, of movement of the patient, or injudicious handling of the limb on the part of those rendering him assistance. When the wound is made by protrusion of the fragments the injury is usually less severe since the wound is smaller, the damage to the soft structures less extensive, and the parts less liable to contamination by dirt, etc. Fractures which are made compound by the fracturing force are usually due to direct violence, and are, apart from the fact of their being compound, more extensive and severe, and more likely to be comminuted than simple ones, since the force employed is greater and the local damage proportional.

Some fractures are almost necessarily compound owing to the situation of the bone, *e.g.* the nasal bones, the lower jaw, and the middle and anterior fossæ of the skull. Punctured and gun-shot fractures are, with very rare exceptions, compound.

The severity of a compound fracture varies within the widest limits, sometimes being but little greater than the simple injury, in other cases demanding immediate amputation, or proving fatal from shock or hæmorrhage. All of them have this danger in common—air, and generally dirt, gain entrance into the wound, and hence, unless great care be taken to ensure cleanliness and strict asepsis, the discharge may putrefy, and septic absorption, with all its attendant dangers, results. The employment of antiseptics has happily reduced to a minimum many of the most serious dangers consequent on compound fracture, chief among which may be mentioned prolonged suppuration, with consequent hectic and exhaustion, necrosis of the fragments, osteomyelitis, and the acute infective processes.

The size of the external wound is by no means necessarily indicative of the actual damage inflicted, for the muscles, vessels, and nerves may be torn and lacerated, or the skin may be widely separated from the deep fascia, its vitality being thereby seriously imperilled.

Compound fractures may be accompanied by the same complications as simple ones (p. 94).

Treatment.—The seat of fracture should be exposed at once,

and means taken to arrest hæmorrhage. The wound should be covered up with a clean towel or handkerchief, temporary splints should be applied, and the patient removed to his home.

Primary amputation.—The first question arising is as to the possibility of saving the limb. In many cases there is no difficulty in deciding this point at once, but in some the decision is a matter for anxious consideration, not admitting of hard-and-fast laws, but being arrived at by a careful consideration of the merits of the individual case.

Certain general indications may be given to guide the surgeon in his judgment.

Since the introduction of antiseptics and improved methods of dressing wounds, many limbs have been saved which in former times would have been unhesitatingly condemned, but while every endeavour should be made to follow the dictates of conservative surgery, it must always be remembered that the patient's life must not be jeopardised by a vain attempt to save a shattered limb. In deciding this important question, the line of treatment must, in many cases, be determined by general considerations; thus those in enfeebled health, the aged, the subjects of grave organic disease —especially of the kidneys—and those broken down by alcoholic excess or privation, are very bad subjects; and although it must be admitted that amputation under such circumstances is a severe measure, yet it will often prove the safest and most judicious course. As regards the extent of the local damage, amputation is almost always necessary if the damage to the soft structures is very great; if the skin is stripped up and bruised, if the muscles are lacerated and pulped, and especially if the fragments are much comminuted, amputation is usually the best means of consulting the patient's safety.

If large nerve trunks are wounded they should be sutured, provided the circumstances of the case offer a reasonable chance of saving the limb. Rupture of the main artery is a very serious complication, and, if combined with much damage to the soft parts, necessitates amputation, especially in the lower limb. If in the face of such an accident it is decided to try and save the limb, the case must be treated as one of primary hæmorrhage, the vessel being secured *in situ*; but should this be impossible, the choice lies between ligature in continuity and amputation. As regards ligature in continuity, it has all the disadvantages mentioned at p. 83, but is a much more serious proceeding in a case of compound fracture than in simple wound of the vessel, and is far more often followed by gangrene. It may be generally stated that if the main

vessel has been wounded in a feeble or aged patient, amputation should be performed; in the robust the vessel may be secured *in situ*, or if this cannot be done amputation should be performed on the lower limb, while in the upper ligature in continuity may be practised; the surgeon carefully watching for signs of gangrene.

Compound fracture implicating a joint is a very serious accident, and may necessitate excision or amputation. If the injury be not very severe, the soft parts not much damaged, the patient of sound constitution and not advanced in years, an attempt may be made to save the limb, particularly if the joint be a small one. In other cases, especially in the upper limb, resection may be performed; the broken fragments must be removed, the joint surfaces trimmed up, and the limb placed in the most useful position in anticipation of permanent ankylosis.

It must be remembered that in all cases of compound fracture of equal severity there is greater likelihood of success, and less danger in attempting to save the upper than the lower limb, and that the danger to the patient in either case increases with the proximity of the fracture to the trunk.

Secondary amputation is a more serious proceeding than the primary operation, since it is necessitated by causes which have placed the patient in a dangerous position, and have rendered him a bad subject for a capital operation. The operation may be required for gangrene, prolonged suppuration with septic absorption and hectic, osteomyelitis, or necrosis of fragments with non-union. Amputation should if possible be delayed until, by appropriate treatment, the morbid process necessitating it has been arrested and the general constitutional disturbance has been abated. If gangrene sets in, amputation should be performed without delay.

If it be decided to attempt to save the limb, the surgeon must spare no effort to secure and maintain asepsis. When all bleeding has been arrested, the wound must be thoroughly freed of all dirt or foreign material, loose splinters of bone must be removed, the bone ends replaced if protruding, and free drainage provided. In cases of compound fracture the broken ends should be united by steel screws or pegs or by wiring, the superficial wound being enlarged for this purpose when necessary.

Bleeding is arrested by ligature or torsion, and capillary oozing, which is often copious and persistent, may be controlled by hot sterilised water or carbolic solution and elevation of the limb. Splinters of bone completely separated from the periosteum should be removed; but if they are still attached they may be safely left,

being replaced as carefully as possible in their right position. If one of the fragments is projecting through the skin it must be replaced with as little damage to the tissues as possible. If the elastic skin has contracted round the projecting fragment, the wound must be enlarged sufficiently to allow of easy reduction; the incision should be as limited as possible, and made in the direction (usually that of the axis of the limb) best calculated to favour reduction and avoid important parts. If in spite of enlargement of the wound the bone cannot be replaced, the projecting portion must be sawn off, the least possible amount being removed. Thorough cleansing of the wound is of the first importance, and, if necessary, the opening must be enlarged to facilitate it. All blood-clot must be cleared out and tags of pulped tissue cut away, so should all tissues into which dirt has been thoroughly ground; the cavity must then be cleansed with 1 : 20 carbolic solution. The syringe should be armed with a piece of india-rubber tubing, which can easily be insinuated into the deeper parts and irregularities of the wound without inflicting additional injury. When the wound has been thoroughly flushed it should be dried as well as possible; efficient drainage must be provided and counter-openings made if necessary.

The question of sutures depends upon the extent and nature of the wound; if it is tightly stitched, adequate drainage will be impossible.

A dry antiseptic dressing must be applied, and should remain untouched unless the discharge comes through, or other circumstances, *e.g.* pain or fever, indicate the necessity for redressing (see p. 11).

Splints are applied outside the dressing, and may require certain modifications according to the position of the wound, so that its seat may be open to inspection.

COMPLICATED FRACTURES

A fracture, simple or compound, may be complicated by some other serious injury in its neighbourhood. The usual complications are dislocation of the fractured bone, implication of the articular surface by the plane of fracture, and wound of the main vessels or nerves.

Fracture complicated by dislocation is more commonly seen in the upper than the lower limb; thus, the head of the humerus may be dislocated and the surgical neck fractured; and dislocations at the elbow are often associated with fracture of the bones (p. 123).

Fracture implicating a joint.—Fractures of the patella, olecranon, etc. necessarily involve the joint. In simple cases the complication is not a serious matter, and although considerable swelling and some synovitis ensue, union occurs normally without any permanent ill-effects. The patient should be warned that the fact of involvement of the joint will entail some degree of subsequent stiffness and pain, which will, however, in ordinary cases ultimately disappear under a course of douching, massage, and passive motion. Limitation of movement is sometimes extreme in fractures of the lower articular surface of the humerus, the olecranon and coronoid fossæ becoming filled with callus; free movement will, however, return when the callus becomes absorbed. When a joint has been implicated by a fracture, it is advisable to apply an ice-bag for a few days to subdue the synovitis, and passive motion should be begun as soon as possible in order to prevent the formation of adhesions.

Fracture with injury of the main artery is always a serious accident.

The fragments may compress, bruise, puncture, or lacerate the vessel, these accidents being most frequently met with in cases of fractured leg. When the vessel is ruptured, a diffuse traumatic aneurism results, causing considerable and increasing swelling with or without pulsation, failure of the pulse below, loss of sensation, and coldness and lividity of the limb (see p. 58). Gangrene is very likely to ensue, especially if the damage to the soft structures is great.

Treatment must be on the same lines as are laid down for traumatic aneurism (p. 59). If complete asepsis can be ensured, and the circumstances of the case justify an attempt to save the limb, the vessel must be cut down upon and secured *in situ*, the clots being turned out and the case then treated as one of compound fracture. If the fracture be already compound, this is the obvious course of treatment when it is decided to save the limb; but if it is simple, and strict asepsis cannot be carried out, proximal compression with elevation may be employed, or the artery may be ligatured in continuity at a distance from the fracture. The comparative advantages of these proceedings are discussed at p. 110.

In many cases primary amputation is clearly indicated, and the secondary operation may be required for gangrene.

Fracture with injury of a nerve trunk.—Large nerves may be compressed, bruised, or lacerated by the fragments, or later on, may be implicated in callus. The musculo-spiral and ulnar nerve at the elbow are very likely to be damaged by reason of their near

relation to the bone, and in fracture of the middle fossa of the skull the auditory and facial nerves are often injured. If there is reason to believe that a large nerve trunk has been damaged, the muscles should be daily stimulated electrically; and if no improvement takes place—thus showing that the function of the nerve has been permanently impaired—it must be cut down upon and sutured if practicable, or freed from callus if embedded therein.

Fracture with wound of a viscus. See Injuries of the Chest, p. 319; Pelvis, p. 341; and Head, p. 230.

SEPARATION OF THE EPIPHYSES

Separation of an epiphysis (Fig. 31) is an accident of early life, usually occurring before the fifteenth year, but very rarely after the twentieth. The injury is usually simple but may be compound, and is caused by direct or indirect violence. Pathological changes at the epiphysary line may lead to spontaneous separation (see chap. v. vol. iii.).

FIG. 31.—Separation of the lower epiphysis and of the great trochanter of the femur of a full-term child. There is an incomplete fracture of the middle of the shaft of the femur. (Westminster Hospital Museum, No. 42. Drawn by C. H. Freeman.)

The epiphyses usually injured are those of the humerus, the lower end of the femur, and the lower end of the radius.

Morbid anatomy.—The line of fracture usually passes along the epiphysary line for some distance, and then traverses the diaphysis, but in some cases—especially in quite young children—the diaphysis is unaffected. There may be little or no displacement, or it may be complete; in the latter case the periosteum is often extensively stripped from the diaphysis, and, the nutrition of the bone being thus impaired, suppuration and necrosis may occur.

Diagnosis.—The age of the patient, the situation of the injury, the increased mobility, and modified crepitus are indicative of the occurrence of this accident. The diagnosis from dislocation presents no difficulty, this injury being distinguished by increased fixity, alteration in the normal relation of the bony landmarks about the joint, and difficulty in reduction, which permanently abolishes the deformity.

Prognosis.—If the patient is not very young, and the line of

fracture passes partly through the diaphysis, and if the fragments can be maintained at rest in accurate apposition, complete repair without any arrest of growth may result. In some cases, however, there is more or less permanent impairment, although the degree thereof has perhaps been exaggerated.

The degree of ultimate arrest of growth will depend upon the age of the patient, the extent to which the epiphysary line is itself affected, and upon the share taken by the epiphysis in adding to the length of the bone. Injury of the upper epiphysis of the humerus or lower epiphysis of the femur is a more serious accident than injury at the opposite ends, since these bones add chiefly to their length by growth at the ends specified. If growth be arrested, the limb remains stunted and the muscles become atrophied and fatty from disuse. In the case of arrest of growth at the lower radial or tibial epiphysis, these bones fail to keep pace with the growth of the ulna and fibula respectively, and hence deformity of the hand or foot results.

Suppuration and necrosis sometimes occur.

Treatment.—Separation of an epiphysis requires the same treatment as an ordinary fracture. If the displacement is complete, it is sometimes very difficult to bring the parts into accurate apposition, and some surgeons have recommended wiring the fragments in such cases.

Should suppuration and necrosis ensue, secondary amputation may be called for.

BENDING AND GREENSTICK FRACTURE

When subjected to violence the bones of children tend to bend, breaking on the convex side (greenstick fracture, Fig. 32).

This form of fracture usually occurs in young children, and not after fifteen years of age. Bones weakened by pathological processes, *e.g.* rickets or osteomalacia, may bend as the result of pressure or muscular action.

FIG. 32.—Greenstick fracture of the radius. The lower epiphysis is absent (Fergusson).

Greenstick fracture is most commonly seen in the clavicle, femur, and forearm bones. The periosteum and soft structures are not damaged, and as indirect violence is usually responsible for the accident, no bruising is present. There is distortion, and perhaps some pain and impairment of movement.

Treatment.—It is often impossible to completely restore the

shape of the bone at once, apparently because the spicules of bone on the fractured side interlock.

All attempts at correcting the deformity must be carefully and gently made, or the fracture should be rendered complete. The deformity need not be completely rectified, as the bone will, in most cases, be found to have assumed its normal shape in a few weeks, partly owing to muscular action, and partly to the natural resilience of young bones—the spicules on the broken side having been absorbed, and thus no bar being offered to reposition.

Greenstick fractures should be kept at rest for ten days or a fortnight, the splints being applied to the limb on the *concave* side of the bend in the bone.

CHAPTER VII

Injuries of Joints

CONTUSIONS

Contusion of a joint causes considerable swelling from extravasation and effusion of blood and sero-synovial fluid, and is accompanied by much pain. The muscles in the neighbourhood may be bruised, and subsequently atrophy. Slight synovitis usually results, but with rest and cold the joint regains its normal state in a few days.

SPRAINS

A sprain is due to sudden violence whereby the joint is wrenched, the force not being sufficient to cause dislocation. The joints usually injured are the knee, ankle, and wrist. The damage inflicted may be severe, and lead to permanent weakening of the articulation.

The ligaments are stretched, and perhaps lacerated, and there is ecchymosis and swelling in and round the joint, and in the tendon sheaths. More or less acute synovitis results, and, if the injury be severe, may lead to chronic hydrarthrosis, or to stiffness from the formation of adhesions in the joint, or external to it. Even a slight sprain may, in predisposed patients, be the starting-point of tubercular synovitis.

Unless due care be taken to ensure complete rest for a sufficient period of time, permanent weakness of the joint may ensue, consequent on imperfect repair of the torn ligaments.

Pain at the time of the accident is usually severe and sickening, and, when effusion occurs, depends on its amount. A severe

sprain is always a serious accident, often impairing the future utility and strength of the joint; even slight injuries of this nature may cause much trouble, as they are often made light of by the patient, and consequently neglected.

Treatment.—The observance of complete rest, with the continuous application of cold to subdue inflammation, are the first indications. If there is much distension of the joint, causing great pain, the blood and fluid should be removed by aspiration.

When all danger of inflammation has subsided, the joint should be strapped or fixed in plaster for ten days, or longer, according to the severity of the injury.

In bad cases it is a good plan, when the pain and swelling have somewhat subsided, to put the joint up in a light plaster casing, which should be worn for two or three weeks.

The future treatment consists in massage, cold douching, and passive motion, partly with a view to promoting absorption of the synovial effusion, and partly to combat the stiffness of the joint.

If the sprain has been severe, the patient should wear a stout leather or poroplastic support for some months. Should adhesions form outside the capsule, or between the joint surfaces, they must be broken down under an anæsthetic and passive motion daily resorted to to prevent their re-formation.

PENETRATING WOUNDS OF JOINTS

An open wound of a joint varies within the widest limits of severity, gun-shot wounds being the most severe, and causing much smashing of the articular surfaces. The gravity depends also upon the size, depth, and importance of the joint, and upon the possibility of removing all dirt, and keeping the parts aseptic.

If the wound in the skin be small, the surgeon may be in doubt as to the involvement of the joint, and under such circumstances he should examine the wound carefully with the finger, especially noting the direction taken by it. To facilitate this the skin may be further incised, but a probe ought not to be used for fear of its passing into the joint through structures not injured by the accident.

The escape of synovial fluid and rapid distension of the capsule by it are diagnostic of wound of the articulation. At the time of injury the patient may experience severe pain, especially if the bone is grazed, pieces of which may be detached.

If the wound is quite small and inflicted with a clean instrument,

no evil results may follow, although slight synovitis with effusion of fluid is met with in most cases. If a foreign body has gained entrance to the joint, or a piece of bone or cartilage has been chipped off, the wound may still heal without trouble, but the patient sooner or later presents the symptoms of foreign body in the joint.

If a wound has been inflicted under such circumstances that dirt has entered the joint, acute septic arthritis, and perhaps pyæmic infection may result, and it is to the possible occurrence of these states that wounds of joints owe so much of their importance.

Treatment.—Absolute cleanliness and perfect rest are essential. If the wound is quite small, and has been made with a clean instrument, it may be closed and covered with a dry dressing. Large wounds, and those inflicted with dirty weapons, must be treated according to circumstances. If necessary, the wound must be further enlarged to allow the surgeon to thoroughly irrigate the joint, and counter-openings must be made for drainage if needful. The superficial wound may be completely or partially closed. If the articular surfaces are damaged, excision or amputation may be required, but no hard-and-fast rules can be laid down for their performance.

Should suppuration occur, the joint must be freely opened, and continuously irrigated with boracic acid solution.

Rest must in all cases be maintained by such apparatus as is applicable to the joint wounded, it being borne in mind that ankylosis may result, and the position must be such as to leave the limb of the greatest possible utility should such occur, *e.g.* the knee extended.

When the superficial wound has healed, and all danger of inflammation has subsided, massage, friction, and passive motion must be employed to promote absorption of any fluid which may be present, and prevent stiffness from the formation of adhesions.

DISLOCATIONS

If the opposed articular surfaces of the bones forming a joint are displaced, the distal bone is said to be dislocated. If the surfaces are completely separated the dislocation is **complete**, but if they remain in contact at any point it is **incomplete or partial.**

The terms **simple**, **compound**, and **complicated** have the same

significance as in the case of fracture. Dislocations are **traumatic**, **pathological** or spontaneous, and **congenital**, according to the circumstances attending their production.

TRAUMATIC DISLOCATIONS

Etiology—Predisposing causes.—Age, sex, occupation, and similar circumstances have the same bearing on the causation of dislocations as on that of fracture (p. 90). Most dislocations occur in active, adult life, and all—with the exception of those at the elbow joint—are rare in children. In old age, violence usually causes fracture of the brittle and atrophied bones rather than dislocation. Muscular weakness or paralysis, and relaxation or stretching of the ligaments from chronic hydrarthrosis, or other causes, predispose to the occurrence of dislocation from slight injury. Ball-and-socket joints are especially liable to dislocation, while hinge-joints as a class are protected, the elbow being a notable exception.

The proximate causes are the same as those of fracture. Most dislocations are caused by indirect violence, but whether the violence is direct or not, muscular action plays by no means an unimportant part in assisting the bone to leave its socket, and in determining the subsequent position of the displaced head. A joint subjected to violence is more likely to be the seat of dislocation if the muscles acting on it, and serving to maintain the bones in apposition, are relaxed and taken, as it were, by surprise; while, on the other hand, spasmodic and strong contraction, acting in combination with violence, may materially help in causing displacement. Dislocation may be caused by muscular action alone without any external violence, as in displacement of the lower jaw or patella.

Morbid anatomy of a recent dislocation.—The capsule, especially if it is abnormally lax, or if the dislocation is incomplete, may be simply stretched, but in the majority of cases it is ruptured. The rent may be small in comparison with the size of the head of the bone which has been forced through it, and thus the capsule, tightly embracing the narrower neck, offers a bar to easy reduction. Other ligaments of the joint are stretched, lacerated, or altered in direction, and may, as in dislocations of the femur, materially assist in determining the position of the dislocated head or offer difficulties in reduction. The muscles and surrounding soft structures are bruised, stretched, or torn according to circumstances. Large nerve trunks and important vessels may be injuriously compressed,

stretched, or even ruptured. The degree of damage to the soft parts determines the amount of extravasation and subsequent swelling. Portions of bone may be chipped off, or the articular surfaces may be fractured, especially if they are irregular and complicated. In other cases the shaft or neck of the bone may give way.

Signs.—The injured joint should always be carefully compared with its fellow. If the case is seen directly the accident has occurred, there will be little or no swelling; but in a very short time swelling and bruising make their appearance, and the former may be so great that difficulty of diagnosis is occasioned, especially if, as is sometimes the case, the limb is rigid, and assumes, on account of bruising and temporary relaxation of some muscles with contraction of others, a position resembling that of dislocation. Under such circumstances the examination should be made under anæsthesia, when the position and fixity due to muscular contraction alone completely disappear. **Immobility** and **alteration of the axis** of the dislocated bone which maintains its new position without support, are diagnostic of dislocation. Immediately on receipt of the injury immobility may not be very marked, since the faintness and probable shock temporarily relax the muscles. If there is fracture of the neck or shaft, as well as displacement of the articular surfaces, mobility will be present, but it will be associated with crepitus, and examination will prove that the movement is not at the joint, but lower down. False crepitus is sometimes felt in dislocations of a few days standing; this is due to the presence of lymph, and may be readily attributed to its true cause by its slight degree and the fixity of the bones. The position assumed by the head of the bone, and hence by the axis of the unbroken shaft, is governed in the first instance by the direction of the violence causing the injury and the place at which the capsule is ruptured (*primary dislocation*); but as soon as the bone has left

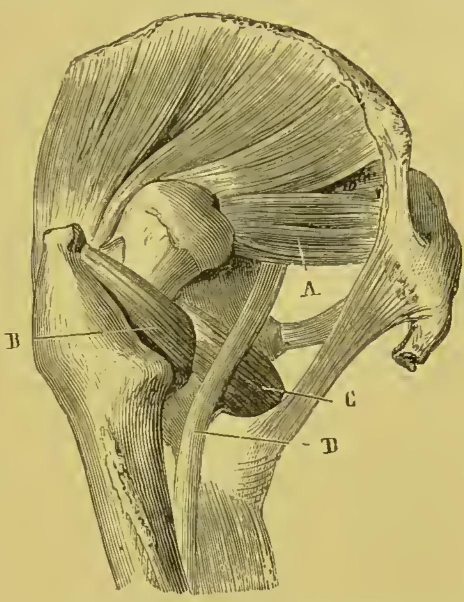


FIG. 33.—Dorsal dislocation of the femur. *A*, pyramidalis; *B*, obturator externus; *C*, obturator internus; *D*, great sciatic nerve (Follin).

the joint, the head may be pulled into another position by muscular contraction (*secondary dislocation*).

By comparison of the two joints it will be evident that on the injured side the normal **relation of the bony prominences** no longer maintains, and the head will be found in a new position. The limb is usually **shortened**, but is **lengthened** in certain cases.

Pain varies in degree according to the damage inflicted on the soft structures and the pressure exercised on nerve trunks. Pressure on a large artery necessarily diminishes the volume of the pulse below. When a dislocated bone has been reduced it retains its position without support in marked contrast to what occurs in fracture; in some instances, however, a bone once displaced cannot be retained in its normal position, although reduction may be easy, *e.g.* dislocation of the scapula downwards.

Prognosis.—If a simple dislocation be reduced early, the soft structures heal readily, the rent in the capsule closes, and but little permanent damage results. The stretched and lacerated ligaments are, however, permanently weakened, so that the joint is less able to bear severe strain, and dislocation may subsequently occur from much less force than originally produced the injury. More or less pain may persist for some time. Slight synovitis is not uncommon, and may sometimes lead to fibrous adhesions, unless care be taken to prevent their formation by early passive motion.

Treatment.—**Immediate reduction** should be effected, since the longer the bone remains in its false position the more fixed does it become. Directly after the occurrence of the injury the muscles are relaxed and there is but little rigidity; reduction therefore may sometimes be easily accomplished without an anæsthetic—indeed, in some cases, *e.g.* the patella, the bone may slip back again owing to the patient's movements. In a very short time, muscular contraction is so strong that an anæsthetic becomes necessary, and should always be given to the full extent rather than that pain, and perhaps additional damage, should be inflicted on the patient by the employment of great force in an attempt to overcome it. When the patient is fully anæsthetised, the only hindrances to reduction are offered by the ligaments and the irregularity of the bone surfaces, which must be overcome by movements based upon anatomical knowledge. Such movements may, however, prove ineffectual, even in the hands of the most skilful, and then the only means at our disposal is forcible reduction by extension and counter-extension.

Reduction by manipulation is the proper method to employ in all

cases which can be so dealt with, for not only is it less painful if employed without anæsthesia, but it is less likely to occasion additional damage to the soft parts than is the more forcible method to be presently mentioned. The movements imparted to the dislocated bone necessarily vary, but they all have a common object, viz. to make the bone enter the joint by the path by which it left it, thus inflicting little or no fresh damage.

Reduction by extension and counter-extension is only employed when manipulation fails; it is a much rougher proceeding, and is liable to cause far greater additional damage than could possibly be effected by manipulation. Extension and counter-extension may be made by the surgeon alone, or with the help of an assistant, but in some cases pulleys may be necessary. The parts to which the extending and counter-extending force is applied must be protected from injury by means of wetted lint or towels. All movements made in attempting to reduce a dislocation must be gradual and sustained, and not jerky or sudden, since, so far as muscular contraction goes, our object is to tire the muscles rather than overcome them by sudden force. In reducing a dislocation in an old person, it is necessary to remember that the bone is very likely atrophied and therefore may be readily broken.

After-treatment.—The dislocation having been reduced the joint must be kept at complete rest for a period varying according to its size and importance, in order that the torn ligaments and other structures may heal. The application of an ice-bag for a few days is very useful, especially if there be much swelling or any synovitis. Passive motion should be commenced at the end of ten days or less, so that stiffness or permanent impairment of movement from matting of the muscles or extra-articular structures, or from the formation of adhesions between the bones, may be averted.

DISLOCATION COMPLICATED BY FRACTURE

The neck or shaft of the dislocated bone may be broken, or the head may be smashed. In the latter case the dislocation is usually compound and resection or amputation will probably be required. When a simple dislocation is complicated by fracture the patient should be fully anæsthetised, and the fracture being set between splints as tightly as possible, an attempt must be made to effect reduction. If successful, the temporary tight splints must be removed and the fracture properly set. If all attempts at

reduction are ineffectual, the fracture must be set, and when it is soundly healed, a cautious attempt at reduction must be made. Under these circumstances the difficulties are much enhanced by the altered state of the parts; moreover, the callus about the fracture is soft and easily broken if any great force be used. If a compound dislocation is complicated by fracture, but without much laceration of the soft structures, it may be reduced and the fracture set; excision or amputation may, however, be required.

DISLOCATION COMPLICATED BY NERVE INJURY

The nerves about a joint may be contused or even lacerated by dislocation; this is especially likely to occur at the shoulder and elbow. They may also be damaged by rough attempts at reduction, and in unreduced cases the trunks may be compressed by the displaced head or involved in dense fibrous tissue. In recent dislocations, if there are signs of nerve injury, some time must be allowed to pass before any operation is undertaken with the view of suture, since the symptoms may be and probably are due to contusion only.

COMPOUND DISLOCATIONS

A compound dislocation is an extremely severe, though happily rare, injury, associated with extensive laceration of ligaments, muscles, and soft structures, and sometimes with injury of important vessels and nerves or fracture of the bone. The elbow, wrist, knee, and inter-phalangeal joints are the usual seats of the accident.

A dislocation may be rendered compound by the head of the bone lacerating the skin, or the wound, leading down to the displaced head, may be inflicted from without. The gravity of the accident and the chances of saving the limb depend upon the degree of laceration of the soft structures, the importance and size of the joint involved, and on the exclusion of septic material. Hamilton considers that an important cause of the acute destructive inflammation which may follow, and which is so serious a source of danger in cases of compound dislocation, is to be found in the fact that the muscles remain on the stretch after reduction, and hence complete physiological rest is not obtained.

Treatment.—Much the same considerations guide the surgeon in judging as to the advisability of attempting to save or sacrificing the limb in a case of compound dislocation as influence him in

compound fracture (p. 110). Other things being equal, amputation is less urgently required in the upper than in the lower limb, and in young and healthy patients as compared with the aged or diseased. Severe laceration of the soft parts, especially if the vessels and nerves are damaged, calls for primary amputation. In some cases an attempt may be made to save the limb after resection of the dislocated head; this is necessary if the joint surface is smashed, or if the head of the bone protrudes and cannot be easily replaced. If an attempt to save the limb is made, secondary amputation may be called for under circumstances similar to those necessitating the operation in compound fracture (p. 111).

If it be decided to save the limb, the dislocation must be reduced under an anæsthetic; the case is then practically one of wound of a joint with laceration of the soft structures. The parts must be thoroughly cleaned by syringing with 1 : 20 carbolic acid, or some other antiseptic solution; loose tags of tissue should be removed with scissors, all hæmorrhage must be arrested and free drainage established, counter-openings being made if necessary. If the wound is large, its edges may be drawn together by a few points of suture, but it should not be tightly stitched lest free escape of discharge be prevented. A dry antiseptic dressing is applied and the joint kept at complete rest by such apparatus as is most appropriate to the special dislocation.

When once the dressing has been applied and the joint fixed in such a position as to relax the muscles, it should be left alone unless the escape of discharge, or the general condition of the patient necessitates redressing. In view of the possible occurrence of permanent ankylosis, the joint should be put up in that position in which it will be of the greatest service, should this occur.

Passive motion should be begun as soon as the condition of the wound allows.

OLD UNREDUCED DISLOCATIONS

If a dislocation remains unreduced, certain changes occur in the bone ends and surrounding structures which may, when advanced, render attempts at reduction futile or even dangerous.

The normal shape of the joint surfaces is altered, depressions are filled up, and the socket flattened or obliterated, partly by absorption, partly by the formation of new bone and fibrous tissue. The articular cartilage disappears by absorption, and the end of the bone becomes covered by dense fibrous tissue; the mutually opposed

surfaces of the displaced head, and the portion of bone against which it rests, become dense, smooth, polished, and ivory-like.

The dislocated head accommodates itself to its new position, the surfaces of bone in contact become adapted to each other, and a more or less perfect false joint is formed, surrounded by a dense imperfect fibrous capsule lined by a synovial membrane (Fig. 34). The bone against which the displaced head impinges undergoes partial atrophy from pressure, but round this area new bony tissue is formed, and thus an imperfect socket results. The lacerated soft parts cicatrise, a dense fibrous scar being formed, to which important vessels and nerves may be adherent. The muscles are permanently contracted or lengthened according to their position.

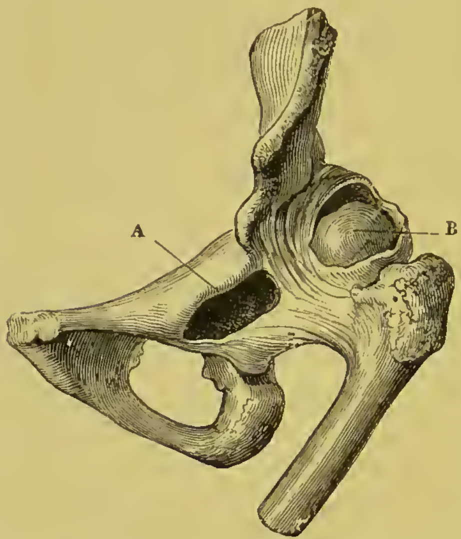


Fig. 34.—Unreduced dorsal dislocation of the femur with the formation of a false joint. *A*, acetabulum; *B*, head of the bone in the new joint (Follin).

A certain degree of mobility gradually returns, and this may be so great that the limb serves all useful purposes.

Long disuse has, however, led to atrophy of the bone with widening of its medullary canal and diminished strength; if but little movement is regained, atrophic changes are more marked, and the shortened muscles undergo fatty degeneration and atrophy. In the case of ginglymoid and arthrodial joints, repair is always very imperfect.

In young patients the changes above described occur quickly; but the time occupied—and hence the period during which we may hope to effect reduction—varies considerably according to circumstances.

Treatment.—The main obstacles to reduction are, the altered shape of the ends of the bones, and the cicatricial contraction of the muscles, ligaments, and soft structures. Even if reduction can be effected, it may be found that the joint surfaces are no longer capable of mutual adaptation, and little, if any, good results. In determining whether an attempt should be made to effect reduction, the surgeon must be guided by the circumstances of the case, paying special regard to the amount of inconvenience caused, the age of the

patient, and the remoteness of the accident. As a general rule, it may be stated that dislocations of the lower limb may be reduced within two months, and those of the upper limb within three months of the accident; but much latitude as regards time is possible.

Anæsthesia is useful and necessary to avoid pain and prevent involuntary muscular contractions; but it is of much less value than it is in recent dislocations, in which muscular contraction is the main obstacle to reduction. Manipulation is less likely to be successful than in a recent dislocation; but it should always be tried, and, if it fails, extension and counter-extension must be employed.

Before attempting the actual reduction, it is necessary, by free movement in all directions, to break down any adhesions which may have formed. Great care must be taken not to use too great force, otherwise severe damage may result, it being remembered that the bones and muscles are atrophied, that vessels and nerves may be adherent to the cicatricial tissue round the head of the bone, and therefore that these or the muscles may be torn. The atrophied bone may be broken unless force is judiciously and not overzealously employed.

If all attempts at reduction fail, we can improve the movement of the bone by massage, cold douching, and passive motion; but if the limb is practically useless, or if there is severe neuralgic pain from pressure on nerve trunks, the dislocated head should be excised and a false joint formed.

PATHOLOGICAL OR SPONTANEOUS DISLOCATIONS

Destructive disease of a joint may result in the gradual displacement of the bony surfaces. This is favoured by softening and relaxation of the ligaments, destruction of the mutually adapted joint surfaces, and filling up of the socket by granulation-tissue. The determining cause is the contraction of the muscles, and dislocation is the more likely to occur if one set of muscles is capable of contracting with greater power and effect than their antagonists. Pathological dislocation may occur, as in Charcot's disease, independently of suppuration, but its most frequent seat is the hip in cases of tubercular arthritis. The treatment of spontaneous dislocation is practically that of the condition giving rise to it. Its occurrence may be prevented by weight extension, or the employment of some form of apparatus for fixing the joint.

CONGENITAL DISLOCATIONS

Inexpert and forcible attempts at delivery in cases of dystocia may result in dislocation of some bone, especially in the limb on which traction has been made. Such dislocations are purely traumatic, and should be reduced at once and treated as such.

True congenital dislocations are due to some condition occurring during intrauterine life. Faulty positions of the fœtus, violent blows on the abdomen of the mother, irregular uterine contractions, intrauterine convulsions, undue contraction or weakness of any set of muscles, and laxity of the ligamentous structures, have all been assigned as causes of congenital dislocation. According to some, the condition is dependent on central nervous lesions. No doubt many cases are due to mal-development of the joint surfaces owing to some inherent vice of the ovum, and are simple developmental defects similar in nature to hare-lip, club-foot, etc., which are sometimes present in these cases. Intrauterine arthritis and hydrarthrosis are sometimes undoubted causes.

Congenital dislocations are most usually met with at the hip or shoulder joints, but are not confined to them. One side only may be affected, or the dislocation may be bilateral.

The treatment is discussed at p. 198.

CHAPTER VIII

Injuries of Nerves, Muscles, and Tendons

INJURIES OF THE NERVES

Anatomy.—The spinal nerves arise by an anterior or motor, and a posterior or sensory root. The nutrition of the former is dependent on the ganglion cells of the cord, and of the latter on the ganglion situated on it. The individual nerves are split up if they enter a plexus, and hence the distribution of the fibres may be very wide, and conversely any group of muscles or sensory area of the body may be supplied from a considerable area of the spinal cord. The cerebro-spinal nerves are almost entirely composed of medullated fibres, which consist of the central axis-cylinder surrounded by a little albuminous fluid, enclosed by the medullary sheath of myeline, outside which is the sheath of Schwann, composed of a homogeneous elastic material with nuclei. The axis-cylinder is a prolongation of a ganglionic nerve cell, on which its nutrition is dependent and whose life-history it follows. The axis-cylinder is the conducting medium which the medullary sheath and sheath of Schwann serve to insulate and protect. Each nerve is composed of bundles of fibres enclosed in a sheath of connective tissue, in which run the blood-vessels (*epineurium*), and this sends prolongations inwards between the compotent bundles (*perineurium*). Each individual fibre is again isolated by a very delicate *endoneurium*.

Sensory nerves terminate in a plexus which is very intimately connected with the tissue they supply, or in special organs such as Pacinian corpuscles, tactile corpuscles, or end-bulbs. Motor nerves, losing all but the axis-cylinder, penetrate the sarcolemma of the muscular fibres, and form motor end-plates.

Nerves are supplied by nervi-nervorum, which end in Pacinian bodies beneath the epineurium.

Physiology.—Nerve fibres conduct to (*sensory or afferent*) or from (*motor or efferent*) the cerebro-spinal axis, and additionally exercise some occult trophic influence on the nutrition of the parts they supply.

Although there is some difference of opinion on the point, it is probable that all sensory fibres can convey sensation of any kind whatever (heat, pain, tactile) in the same way that in whatever manner a motor nerve is stimulated, it always results in movement; when a sensory nerve is stimulated at any part, the resulting sensation is referred to its peripheral distribution.

Intermittent stimulation of a motor nerve (as by the Faradic current) throws the muscle into tetanus; continuous stimulation (as by galvanism) produces no effect unless the intensity of the stimulus be altered, as in making or breaking the voltaic current.

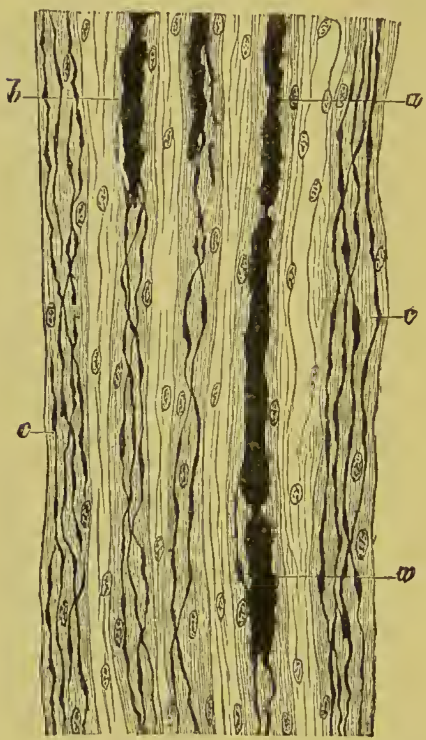


FIG. 35.—Old and newly-formed nerve fibres from an amputation stump (Ziegler). *a*, *b*, old nerve fibres from which several young nerve fibres have grown out; *c*, neurilemma of young nerve fibres.

DEGENERATION AND REPAIR OF NERVES

When a nerve is divided the peripheral portion, being separated from its connection with the ganglion cells, undergoes degeneration; the proximal end, being still in connection with the nutritive centre, does not degenerate to any appreciable extent, but may become bulbous.

Degenerative changes make their appearance within two or three days, and in as many weeks may extend along the whole peripheral portion. The extent and degree of the degeneration is less if the nerve has been sutured.

Degeneration is marked by increase and proliferation of the protoplasm and nuclei of the nerve sheath, and by splitting up of the myeline, which is ultimately removed by the leucocytes and connective-tissue corpuscles. The axis-cylinder is similarly destroyed, and in a few days cannot be distinguished.

The stage of degeneration is followed by repair, and if the ends of the nerve have been sutured and they unite, the repair is permanent; but if no union occurs, secondary and permanent degeneration follows the attempt at repair. Repair is effected by the growth of new axis-cylinders, which are probably developed from the nuclei of the sheath of Schwann.

SECTION OF A NERVE

Complete section of a mixed nerve will produce the following results:—

Motor changes.—The muscles are immediately paralysed; they lose "tone," and are consequently flabby and lifeless. Rapid atrophy follows, and towards the end of the first or second week the muscular fibres will be found to be diminished in size, cloudy, and granular, and to have lost their cross striation. The fibres ultimately disappear, and are replaced by fibrous tissue, which is developed from the interstitial connective tissue. If, however, repair of the injured nerve takes place so that it can conduct impulses, the muscles will eventually become completely restored, although restoration may take many months.

The electrical excitability is quickly diminished, and, keeping pace with the nerve degeneration, is lost in about a month. The "reaction of degeneration" is also present; this is characterised by loss of Faradic irritability and slight increase of galvanic irritability, which is, however, changed in quality; the anodal closing contraction (A C C) is greater instead of less than the kathodal closing contraction (K C C), contrary to the normal condition. Finally, when the atrophy is complete, electrical stimuli produce no effect.

If regeneration of the nerve occurs, voluntary motion returns before the electric excitability. In consequence of the motor paralysis, deformity may result from the uncontrolled action of the non-paralysed muscles, or from the contraction and consequent shortening of those which are paralysed when the part is placed in an abnormal position, and the connective tissue, which replaces the muscular fibres, gradually contracts and maintains such abnormal position.

Sensory changes.—Sensation is abolished in the area supplied by the damaged nerve. Sometimes the abolition is incomplete, as the areas of distribution of sensory nerves overlap, and, moreover, in a short time, there may be a slight return of sensa-

tion owing to the free anastomosis of nerve branches (*recurrent sensatian*). This is important as regards the prognosis of primary suture.

Sometimes there is more or less severe pain in the area, which is apparently analogous with the temporary increase of voltaic excitability after section of motor fibres. Muscular pains seem to be due to slight inflammation of the connective tissue between the fibres. In estimating the sensory condition of a part, the patient's eyes must be closed, and the examination be conducted by means of light touches, as the use of a pin or some fine object, such as a pair of compasses; rough handling is misleading, since the sensation may be conveyed to parts, the nerves of which are intact. It is not only necessary to determine the fact that the patient can feel, but also whether or not he can accurately localise the situation of the point stimulated, and can appreciate one or more points of contact.

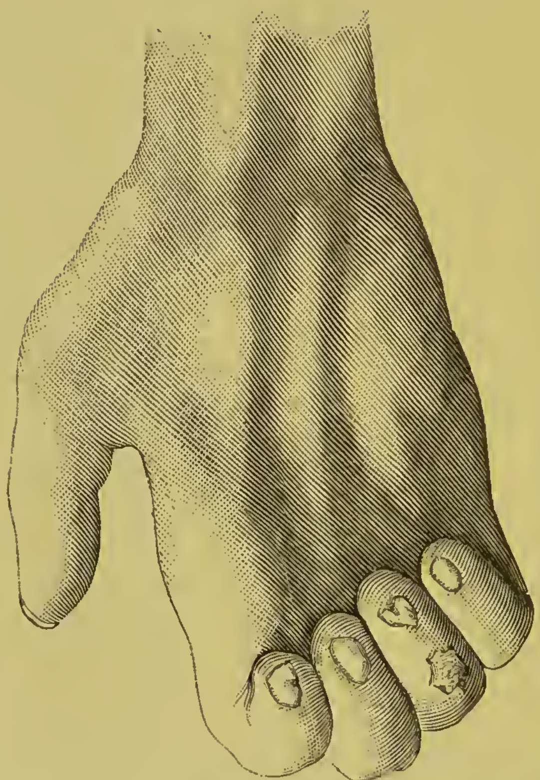


FIG. 36.—Trophic lesions of the nails and skin and atrophy of the interossei and palmar muscles consecutive to section of the median and ulnar nerves (Follin).

Vasomotor and trophic changes (Fig. 36).—After section of a nerve there is slight hyperæmia, with increased heat of the part which it supplies, followed, very shortly, by venous congestion and coldness.

The trophic changes in the muscles have been already mentioned, and although the atrophy and wasting is in the main due to the withdrawal of the trophic "impulse," it must not be forgotten that the mere paralysis of the muscles and the vasomotor changes may also contribute.

After a time the skin will usually be found to be dry and withered, but it is occasionally œdematous, and covered with sweat; typically it is smooth, red, glossy, and wasted. There is

associated wasting of the subcutaneous tissue, and, in the case of the fingers, this renders them pointed. Sometimes this condition is associated with very severe burning pain.

Instead of the skin and subcutaneous tissue being atrophied, and the epidermis thinned, they may overgrow, so that the part is increased in size; but this is rare. The nails and hair (appendages of the skin) participate in the process. The nails become longitudinally curved, scaly, brittle, jagged at the free margins, and transversely ridged; they may be much thickened, dense, and horny.

The hair covering the anæsthetic area becomes short, brittle, and falls off, much more rarely it increases in coarseness and profusion.

The skin may readily blister, and the raw surface may develop persistent ulcers, or even slough; painful ulcers are not uncommon at the roots of the nails where the atrophied skin retracts, and gangrene of the finger tips, similar to that seen in Raynaud's disease, is occasionally met with.

Eczematous and vesicular eruptions are not uncommon; they may occur within a few days of the nerve lesion, and may lead to intractable ulceration or suppuration beneath the epidermis (superficial whitlow).

The joints may undergo slow inflammation, resulting in permanent adhesion and deformity, sometimes, though rarely, accompanied by considerable articular pain; the joint affection usually comes on within a few weeks of the injury, but may be a later manifestation. Epilepsy occasionally occurs as a direct result of peripheral irritation.

Partial section of a nerve gives rise to motor and sensory changes, depending for their extent upon the actual amount of damage inflicted. Trophic changes may occur, but are unusual.

Treatment of nerve section.—The divided nerve must be carefully sutured. If primary suture has been neglected, or has failed in its object, the nerve must be exposed and united later on (secondary suture).

Operation of primary suture.—When all bleeding has been arrested the wound is thoroughly cleansed, and, if necessary, enlarged, so that the divided nerve may be fully exposed. If this has been cleanly cut, the ends are united by chromic gut, by fine threads of kangaroo tendon, or by silk, introduced by means of an ordinary round sewing-needle, which causes the minimum amount of damage. The suture should be passed through the entire thick-

ness of the nerve about a quarter of an inch from the cut end. If the nerve is a small one a single suture is enough, but two or more must be used in the case of larger trunks.

Great care must be taken not to pinch or otherwise damage the ends of the nerve.

If a piece of nerve has been torn away, or is damaged beyond hope of repair, so that its removal is necessary, the nerve must be stretched sufficiently to permit of accurate approximation without tension, or if this is impossible, nerve-grafting must be performed. When the wound has been carefully dressed, the part must be placed in the position best calculated to relieve all tension.

Prognosis of primary suture.—The ultimate prognosis of the primary suture is good, and although the inevitable degeneration may lead to secondary trophic changes, such as occur when suturing has not been performed, their appearance must by no means be taken as evidence that the operation has failed.

Primary suture limits the extent and degree of degeneration and hastens repair, but the full beneficial effects of the operation may not be apparent for months, or even years.

Sensation returns first, then the ability to localise, followed by an appreciation of pain and temperature. The return of muscular power is necessarily delayed, for not only must the nerve be able to conduct, but the atrophied muscular fibres have to be repaired before they can respond to the stimulus. If suppuration of the wound occurs primary suture may fail, and will very likely do so.

The operation of secondary suture is required if the nerve was not united primarily, or if the operation has failed to induce union, but seeing that the result of primary suture may not be apparent for some months, sufficient time must elapse before a secondary operation is contemplated. The operation should be bloodless. An incision is made over the nerve, and the cut ends are fully exposed and freed from adhesions by dissection. If there is any difficulty in finding the distal end, the nerve should be sought some distance below the cut end and traced upwards. The distal end is freshened by removal of a small portion only, and it must be borne in mind that this end, being degenerate, will not present the appearance of normal nerve; the proximal end will be bulbous, the bulb is formed of new connective tissue, and fine wavy nerve fibres; the greater part of the bulb should be removed, and the sutures must be passed through its base, which not only affords a good hold, but the new nerve fibres aid the subsequent union. If the ends are widely separated, the nerve must be stretched to bring them in

apposition, or if this cannot be effected a graft must be interposed.

Prognosis of secondary suture.—In the majority of cases the ultimate prognosis is good; it becomes less so the more remote the time of its performance from the original injury; but Bowlby cites cases showing that some benefit may be derived even after twelve years have elapsed. If it is performed any time during the first year complete recovery may be anticipated; but after this time complete restoration of function can hardly be expected and some permanent stiffness and weakness of the muscles and joints is probable. Yet in all cases the operation should be performed, since it can do no harm and the beneficial results may be surprising.

Nerve grafting is best performed by exposing and freshening the ends of the divided nerve as for suture, and then interposing a piece of nerve taken from a recently amputated limb or from the sciatic of a rabbit; the grafted portion is united to the cut ends by suture. It has been proposed to obtain a graft by splitting the proximal end of the divided nerve, and turning half the thickness down into the gap and fixing it to the proximal end. In some cases very satisfactory results have been obtained by grafting, in others failure has followed, but seeing how disastrous are the results of nerve section the operation should always be employed when the cut ends cannot be approximated.

Treatment during the period of repair after suture or grafting.—After suture of a nerve a variable, often a long, time must elapse before it is capable of reconducting impulses, and during this period means must be adopted to minimise the effects of its deficiency. Muscular wasting may to some extent be certainly diminished by artificial stimulation by the voltaic current, the number of cells used being only such as will produce an effect. Each muscle should receive separate attention and the galvanism should be daily used for from ten to fifteen minutes. If a long time has elapsed since the injury, the time expended must be longer, since it often happens that the muscles do not react until the current has been applied for some little time. As improvement takes place the sittings may be shortened and the number of cells employed reduced.

Massage, friction, and kneading also prove beneficial to the muscles and should be used daily; by their use the nutrition is improved and deformity due to muscular contraction and stiffness of the joints may be overcome. Pain and trophic lesions, such as ulceration, must be treated on ordinary principles.

COMPRESSION OF A NERVE

Causes.—A nerve may be gradually compressed by a tumour or an aneurism, by its involvement in callus or scar tissue, or by the dislocated and unreduced head of a bone, especially the humerus.

More rapid compression may be caused by the pressure of a crutch (see p. 146), by a recent dislocation, and occasionally by a faulty position of the limb during sleep.

Signs.—During the early stages of gradual compression (while the nerve is irritated) there is cutaneous hyperæsthesia, tingling, formication, and perverted sensation along its distribution; irritation of the motor fibres may cause painful cramps and muscular spasms. Very soon, as the continued compression interferes with the conductile power of the nerve, sensation is diminished or abolished, and the muscles become gradually weaker until they are eventually paralysed and wasted. Unless the pressure be relieved secondary neuritis will probably ensue.

Treatment.—Removal of the compressing agent is followed by return of sensation and subsequently of muscular power; the time at which improvement may be expected varies according to that during which the symptoms have been present.

During recovery the after-treatment applicable to cases of nerve section must be adopted. If, after removal of the cause, recovery does not occur, and especially if the symptoms get worse and trophic changes make their appearance, the nerve should be exposed, freed from adhesions (to which the failure of recovery may be due), and stretched.

CONTUSION OF A NERVE

In mild cases of contusion the patient experiences, along the peripheral distribution of the nerve, transitory tingling or burning pain which is not severe and may pass off in a few minutes or last a day or two according to the severity of the blow.

When the contusion has been severe the effects are similar to those met with in cases of section, and the nerve fibres may undergo the same process of Wallerian degeneration, followed by repair. Traumatic neuritis may occur and run a chronic course.

In some cases motion is lost while sensation is but little impaired, since the conducting power of the motor fibres seems to be more readily abolished than does that of the sensory. If Faradic

excitability of the muscles is present, it is certain that the nerve has not been divided. When paralysis results from contusion, the subsequent wasting of the muscles is much less rapid and does not attain such a high degree as is the case after section. The motor and sensory effects of contusion may only be present over part of the area of distribution of the nerve instead of affecting the whole as would be the case after *complete* section of the nerve. In the severest cases many months may elapse before complete restoration of function is established, during which trophic changes may occur in the skin, muscles, and joints. In rare instances cure does not take place owing to the supervention of chronic neuritis and the formation of adhesions.

Treatment.—Complete rest is essential, and if there is much pain indicative of the occurrence of neuritis the application of leeches and warmth should be employed. During recovery the muscles should be stimulated by the Faradic and voltaic currents and friction and massage should be daily employed. If neuritis becomes chronic and recovery comes to a standstill the nerve should be exposed at the seat of injury, with the view of freeing it from adhesions and stretching it.

TRAUMATIC NEURITIS

Acute or chronic neuritis may follow on any injury to a nerve.

Traumatic neuritis usually begins in the sheath (**perineuritis**) and may extend in the nerve along the connective tissue (**parenchymatous neuritis**). There is a special tendency for all forms of neuritis to spread along the nerve trunk, especially the proximal portion, and in some cases the disease may even reach the cord. The vessels are congested, and there is an effusion of leucocytes and lymph beneath the perineurium and sometimes between the individual bundles of fibres, and consequently the inflamed nerve is red and swollen. As organisation takes place the new scar tissue compresses the nerve fibres which undergo peripheral degeneration; the adhesions also bind the nerve to the tissues among which it lies.

Suppuration is extremely rare, and even in cases in which nerves have for a long time been bathed in pus they do not participate in the morbid process.

Signs.—There is pain radiating along the nerve from the seat of inflammation; it is worse at night and may be very severe. The pain is of a burning character and is often increased by pressure;

sometimes it is distinctly mapped out along the course of the nerve, at others the whole limb is affected so that its true origin may be masked. If the nerve is so placed that it can be felt it will be found swollen and tender, and the slightest pressure causes excruciating agony. At first there may be painful spasm and cramp of the muscles consequent on irritation, but if the nerve fibres degenerate from pressure, this is followed by weakness and ultimate paralysis, with rapid wasting and trophic changes such as occur after section of a nerve. The reaction of degeneration may also be present. Acute neuritis may gradually subside and the symptoms clear up in a few weeks, but the progress of most cases is chronic, and many months must elapse before complete cure takes place, especially if trophic changes have occurred.

Treatment.—All sources of irritation must be removed. During the acute stage complete rest, leeches, and hot fomentations may give much relief and cut short the inflammatory process. Pain may necessitate the use of hypodermic injections of morphia, but care is necessary in its use, since the disease is often of long duration and the morphia habit may be contracted.

Mercury and iodides should be given and often produce much benefit.

In chronic cases free blistering along the course of the painful area does much good, but the blisters must not be applied to anæsthetic parts or troublesome ulceration may ensue; in obstinate cases the actual cautery is sometimes necessary. Galvanism and Faradism with weak currents should be used daily. If it is probable that the nerve is being irritated by the adhesions round it, it should be exposed, freed, and stretched. If trophic changes appear they must be treated on ordinary principles.

Injuries of Muscles and Tendons

CONTUSION OF MUSCLES

Muscles are frequently bruised and strained. The accident causes considerable tenderness and pain, accompanied by more or less inability to use the muscle to its full extent, with consequent rigidity. Weakness may persist for some time and wasting occasionally follows; this may be extreme if the nerve has also been contused, as is often seen in the deltoid with bruising of the circumflex nerve.

Treatment.—Rest and confinement of the muscle by bandaging for a few days should be enforced, but when the pain has

somewhat subsided, gentle passive motion, douching, friction, and massage should be daily employed. If the muscle wastes, electrical stimulation must be resorted to.

WOUNDS OF MUSCLES AND TENDONS

The nature of a wound of muscle depends upon its method of production, and the amount of gaping is proportionate to the degree of the injury and to the direction of the wound; when a muscle is wounded transversely to its long axis the gaping is considerable. Tendons, especially those about the wrist, are frequently divided. Machinery and similar accidents which occasion laceration of the tissues may cause considerable tearing of the muscles which usually give way at the junction of the tendons with the muscular fibres, although this may be some distance from the actual seat of the superficial wound. If the fascia over a muscle is torn, the latter may project through the rent (*muscular hernia*).

Treatment.—Divided tendons should always be accurately sutured with silk or kangaroo-tendon; the sutures must be passed through the whole thickness of the tendon and be sufficiently numerous to hold the cut ends in apposition in spite of any muscular contraction which may ensue; they should be inserted about one quarter of an inch from the cut end so as to afford them a firm hold. The necessity for suturing muscles must be determined by the extent and nature of the wound; kangaroo-tendon, silk, or chromic gut must be used.

In all cases the part must be kept at perfect rest for about three weeks, and should be placed in such a position that the muscle is relaxed to the utmost and there is no strain at the seat of injury. Muscular movement may also be restrained by firm bandaging.

If any stiffness is present after union is complete, passive motion, friction, and massage must be daily employed with the view of breaking down any adhesions which have formed.

SUBCUTANEOUS RUPTURE OF MUSCLE OR TENDON

Muscular tissue is very rarely torn unless it is atrophied and degenerated; the accident may, however, be occasioned, especially in those past middle life, by some sudden and violent contraction.

Tendons yield much more readily than does the muscular tissue. The long head of the biceps, the triceps tendon, and the tendo Achillis are those most usually ruptured. The adductor

muscles of the thigh may be torn during riding; the abdominal muscles may give way during parturition, or in tetanus, or the psoas may rupture during violent exercise; the sterno-mastoid is occasionally partially lacerated during birth, giving rise to a hæmatoma in the muscle and the subsequent formation of a tumour of scar tissue (Sterno-mastoid Tumour).

Signs.—Rupture of a tendon is indicated by a feeling of something suddenly giving way, accompanied by loss of power. There may be a distinct snap similar to that heard when tenotomy is performed. If the muscular tissue is torn there is (especially if the rent be large) considerable hæmorrhage causing swelling and subsequent bruising. The loss of power varies with the muscle damaged and the extent of the injury; an attempt to throw the muscle into action causes considerable pain. If the muscle or tendon be superficially placed, examination will show that there is a gap in the continuity, and that this is increased during contraction of the muscle, while the tendon does not become prominent. When rupture affects a deeply-seated muscle the diagnosis is very difficult.

As a rule the blood is quickly absorbed and repair of the damage is effected, but in some cases suppuration may follow; this seems to be specially likely to happen when the fibres of the psoas muscle are torn.

Repair of muscle and tendon is effected by means of fibrous tissue. The blood poured out between the torn ends is replaced by lymph, which becomes vascularised and fills up the gap. The lymph organises into fibrous tissue as in the union of wounds elsewhere; the repair of a tendon is practically perfect, the new tissue being scarcely distinguishable from normal tendon. If the tendon has been united by sutures, there is no subsequent lengthening; but if a gap be left, the tendon is lengthened by the same amount—upon this depends the successful treatment of contracted tendons by tenotomy. Muscular tissue is repaired by dense fibrous tissue; it occasionally happens that new muscular fibres are formed, but complete physiological repair never occurs.

Treatment.—When a muscle has been torn the part must be placed and maintained in that position, which will ensure apposition of the ends and perfect rest. Its contraction may be limited by the firm application of a bandage or by strapping. A ruptured tendon should be cut down upon and sutured, provided strict asepsis can be assured.

Complete rest must be ensured for about three weeks, so that

the fibrous cicatrix may be strong enough to withstand the force put upon it when the muscle contracts.

The subsequent stiffness (which must be expected) should be combated by warm douching, friction, massage, and gentle passive motion. The patient often complains of weakness, and a sense of insecurity about the damaged muscle for some time after repair, which is best treated by giving the muscle support by means of firm bandaging or strapping, or by wearing some form of elastic or leather support.

If suppuration occurs, the abscess must be opened and treated on ordinary principles.

DISLOCATION OF TENDONS

Tendons are occasionally displaced from the grooves in which they normally lie; the most notable example being that of the long head of the biceps (see p. 169); the accident also sometimes occurs to the tendons behind the ankle. The treatment is by no means satisfactory, as the tendon can with difficulty be kept in place while the wound of its sheath is healing; such repair is, moreover, often too feeble to keep the tendon from slipping out again. Fortunately after a time the tendon becomes adapted to its new surroundings, and but little inconvenience results.

CHAPTER IX

Injuries of the Upper Extremity

Many injuries of the upper limb are necessarily common to other parts of the body and offer no special peculiarities. Generally speaking, injuries of this limb are less severe than those of the lower, and they are more frequent.

Wounds of the palm and fingers.—These wounds, apart from causing damage to tendons, nerves, and vessels may, especially if punctured and inflicted with dirty instruments, lead to serious results. In many cases micro-organisms are introduced at the time of the accident, or subsequently find their way into the wound, which appears so trivial, that it too frequently receives no treatment until a septic suppurative inflammation has been excited. All wounds should be most carefully cleaned and protected from contamination by an antiseptic dressing.

Suppuration beneath the palmar fascia may extend upwards by the side of, or in the tendon sheaths, into the cellular planes of the forearm, and owing to the involvement of the tendinous structures much lasting damage may result. Pus in the palm causes much pain; when it is beneath the unyielding fascia, there is redness and œdema on the back of the hand, the fingers are bent, and the palm cupped to relieve tension. If any signs of inflammation make their appearance, the hand should be at once placed in a boracic arm-bath, or enveloped in hot fomentations, and if tension is manifest, it must be relieved by timely and free incisions so placed as to avoid important structures. The cuts should when possible be made beyond the level of the palmar arches and in the line of the metacarpal bones, so that the vessels and nerves are avoided (Fig. 79, vol. iii.). If the suppurative process extends to the forearm or back of the hand, the pus must be evacuated by incisions in these regions.

If neglected, the inflammation may prove dangerous, not only to the limb, but to life itself, more especially as it is usually met with in patients out of health and who are too often the subjects of chronic alcoholism.

Wound of the palmar arches and their branches may be caused by mere punctures, by pieces of glass, or by cuts, and if the deep arch is wounded, may be complicated by division of the nerves or tendons lying superficial to it.

Treatment.—If the superficial arch is divided, the cut ends should be secured *in situ*, the wound being enlarged if necessary, and the same plan should be followed in the case of the deep arch; but enlargement of the wound must be most carefully performed, or important structures may be damaged. If in the case of the deep arch attempts to secure the bleeding vessel in the wound fail, it is better at once to ligature the brachial in the middle of the arm. Ligature of the radial and ulnar may not arrest the hæmorrhage, or at least may do so only for a time, as the blood will be brought to the arch by the interosseous branches. Compression is not altogether free from danger and cannot with safety be maintained long enough to ensure success; if it is attempted, the hand and forearm should be fixed on a back splint and a small graduated compress placed over the vessel and bandaged on with only just sufficient pressure to arrest the bleeding. If great pressure is used, the hand will be completely exsanguined and inflammation and sloughing of the palm will ensue. The compress should be removed in a few hours. Many surgeons advocate compression rather than a resort to ligature of the brachial.

Styptics are never to be used in the palm, as they too often excite destructive inflammation.

Wounds of the wrist.—Owing to the number of bones and synovial membranes entering into the formation of the wrist joint, wounds involving it are serious, and liable to be followed by suppuration, and perhaps necrosis of individual carpal bones. Every care must be taken by the use of antiseptics to avoid such a disaster. Cuts above the wrist very often divide tendons and nerves, and, unless these are immediately sutured, considerable trouble, necessitating later operation with less chance of success, will be occasioned. When the wound has been properly attended to and dressed, the forearm and hand must be placed on a splint, the wrist being flexed to relax the structures.

Sprained wrist is a very common accident, and usually results from a fall on the outstretched hand. There is always great pain,

swclling in and round thc joint, and loss of funetion. Cold applica-tions should be used for some days, to bc sueeeedcd by douching and passive motion, as soon as the pain caused is not too severe. If sprains are rested for too long a time, the movcments may be seriously impeded by adhesions in the joint, and by bands of lymph in the tendon shcaths, whieh will require breaking down undcr gas, and tcdious and painful passive motion subsequently.

Lacerated wounds and crushes of the hands.—The fingers may be torn away by maehinery or other aeeidents, and in such eases the tendons may be dragged out, the muscular fibres yielding.

The stump lcft must be trimmed and dressed, and the forearm earefully bandaged to ensure rest of the damaged museles.

When a hand has been crushed or eaught in maehinery, so that part of it has been irreparably damaged, every eare should be taken to preserve as mueh of it as possible; even one finger being most useful, especially if the thumb has been saved (see p. 216).

Needles and similar objects may be embedded in the tissues, the hand, for obvious reasons, being the most usual situation (Fig. 37). If the foreign body is dirty, serious septie inflamma-tion may ensue; but in other eases it may remain embedded and beeome encysted without doing any harm, although some pain may be oeeasioned. Museular aetion sometimes moves needles a long way from the point of entry, and may eventually bring them to the surfaee. The situation of a needle may be quite evident and elearly indicated by the patient, or diseoverable by the surgeon's finger; if not, its situation ean be aseertained by the Röntgen rays, the cmployment of whieh must be quiekly followed by operation before the needle has time to shift its position. A powerful magnet and galvanometer have been sueeessfully uscd in loealising the seat of needles. No attempt should be made to find a needle by opera-tion until its exaet position has been certainly ascertained, as experienee shows this to be useless; but if its position is eertain, it should be gently cut down upon, exposed, and removed. All manipulation must be delieately performed, or the needle may be driven more deeply into the tissues and thus lost.

INJURIES OF THE MUSCLES

In eases of avulsion of fingers in machinery aeeidcnts, the museles attached to thcm may be completely torn away at the junetion of the tendon and fleshy fibres. The tendons at

the wrist are, as stated above, often divided, and require immediate

FIG. 37.—A needle embedded in the soft structures covering the first phalanx of the thumb (Skiagram by H. Montague).

suture. The long head of the biceps may be ruptured or displaced

(see p. 169), or the fleshy bellies of the biceps, triceps, or deltoid may be more or less lacerated. Other muscles of the upper limb are less liable to these accidents. Rupture of a muscle causes considerable pain and ecchymosis, and a gap may be felt in it. The muscles of the forearm and tendons at the wrist are sometimes strained by constant use, slight tendo-synovitis resulting.

Bruising may be caused by blows or falls; it is attended by pain in movement, and often by temporary paralysis and atrophy, especially if the nerves have been simultaneously injured and traumatic neuritis induced.

Bruising and atrophy of the deltoid is not uncommon after falls upon the shoulder; atrophy also ensues on ankylosis or disease of the joint, or injury to the circumflex nerve, as in dislocations. The movements of the arm are diminished, abduction being especially impaired; the rounded contour of the shoulder is lost, and the bony prominences are very distinct. The treatment of these conditions is described on p. 138.

INJURIES OF THE NERVES

The nerves of the limb may be divided by wounds, the median and ulnar at the wrist most usually suffering; or they may be torn in dislocations or fractures, or implicated in the callus of repair; by the former accident the circumflex is most likely to be injured, by the latter, the musculo-spiral in the middle of the arm, and the ulnar at the elbow.

Musculo-spiral paralysis may also be due to the pressure of a badly-padded crutch (*crutch palsy*), or to lead-poisoning; in the latter case the supinator longus muscle escapes.

Wrist-drop is characterised by semi-flexion at the elbow, with inability to extend the forearm, which is pronated, though capable of some degree of supination by the biceps. The thumb is abducted and the fingers flexed, but the latter can be partially extended by the interossei and lumbricales. The treatment of musculo-spiral paralysis varies with its cause; if due to crutch palsy, the cause must be removed; if to lead-poisoning, the bowels should be freely acted on by sulphate of magnesia, and iodide of potassium administered; if to implication by callus, the nerve must be freed by operation; and if to division, by a knife, or as the result of fracture, it must be sutured. In all cases the treatment by electrical stimulation, massage, and douching must be assiduously carried out (see p. 135).

Fractures

FRACTURE OF THE CLAVICLE

While the peculiar shape of the clavicle protects it against fracture, the position of the bone and the part it plays in transmitting force from the upper limb to the trunk render this the most common fracture in the body. In nearly all cases the accident is due to violence applied to the shoulder, more rarely through the elbow or hand.

Fracture by direct violence is very rare, and when it occurs is often comminuted. Greenstick or incomplete fracture of this bone is not uncommon in children.

Morbid anatomy.—The clavicle is usually broken at the middle, *i.e.* the weakest part, and the line of fracture passes obliquely from above downwards and inwards. The inner fragment is held in position by the rhomboid ligament, although its outer end may be drawn slightly upwards by the cleido-mastoid muscle. The inner end of the outer fragment is displaced inwards beneath the sternal fragment, and backwards, and the whole fragment is drawn down by the weight of the limb.

FIG. 38.—Fracture of the clavicle showing the displacement of the fragments by muscular action (Follin).

The inward displacement is due to the tension of the pectoralis major and latissimus dorsi muscles; the backward displacement to the fact that the muscles, passing from the trunk to the shoulder, tend to pull the latter forwards, and hence the inner end of the outer fragment is tilted backwards.

If the line of fracture passes between the conoid and trapezoid ligaments, there is practically no displacement, since these hold the fragments in position.

Fracture external to the trapezoid ligament is indicated by marked tilting of the outer fragment, which is drawn forwards and inwards with the shoulder and lies at a right angle with the rest of

the bone. Very rarely, the bone gives way at the sternal end, either internal to or through the rhomboid ligament, which prevents displacement.

Signs.—There are the usual signs of fracture, coupled with the displacement of the fragments. Pain and crepitus are easily elicited by gentle movement of the arm, which the patient supports by placing his other hand beneath the elbow or forearm. The head is usually slightly inclined to the injured side in order to relax the muscles. The two sides should always be carefully compared.

Complications.—In spite of the proximity of important structures fracture of the clavicle, being almost invariably occasioned by indirect violence, is seldom complicated.

In fractures by direct violence the upper ribs may be broken, and the subclavian vessels or brachial plexus damaged. Temporary partial paralysis may result from contusion of the plexus, but if any cord be torn the paralysis is permanent. Compound fracture is of great rarity, except from gun-shot injury.

Prognosis.—Union is complete in from two to four weeks, according to the age of the patient. There is always a good deal of callus thrown out, since it is impossible to secure absolute immobility during treatment. Some deformity is permanent, and the patient ought to be warned of this at once in order to prevent disappointment. Fibrous union and false joint are very rare.

Treatment.—Of the many means which the ingenuity of surgeons has devised for the treatment of fractured clavicle, none is entirely satisfactory, owing to the extreme difficulty of obtaining accurate and permanent apposition of the fragments.

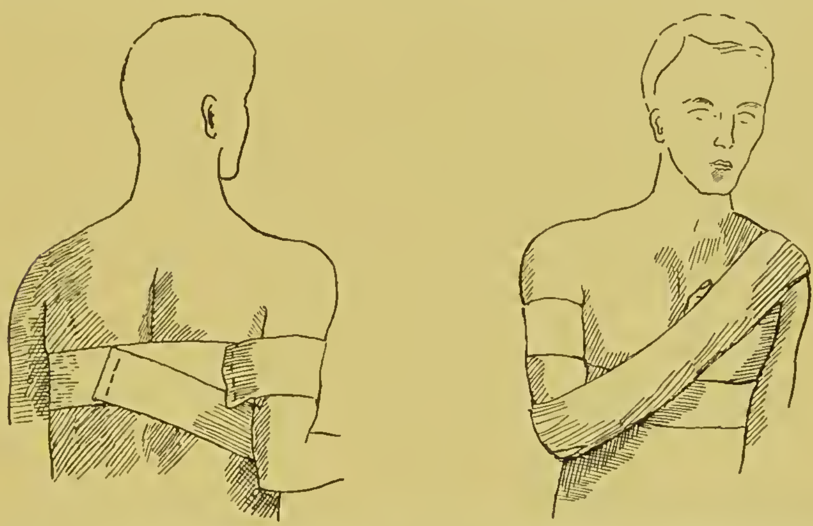
If it be very desirable, as in the case of young ladies, that the permanent deformity should be reduced to a minimum, treatment in the dorsal position is best. The patient should be placed flat on the back on a hard level mattress; the arm should be fixed to the side with a small pad in the axilla and the head raised on a small pillow to relax the muscles. This position must be observed for three weeks and will be tolerated by very few.

Sayre's method is easy of application, requires nothing but a little strapping, and gives, under ordinary circumstances, perfectly satisfactory results.[1] A small pad may be placed in the axilla if there is much over-riding of the fragments with displacement inwards, but it is not always necessary or advisable, as it may compress the axillary vein. One end of a piece of strapping about four inches broad and long

[1] For a description of other methods the reader is referred to a work on Fractures.

enough to encircle the arm and trunk is then passed round the middle of the injured arm (the sticky surface away from the skin) and the loop stitched on (Fig. 39). The strapping is now passed behind the back (the sticky surface being against the skin), round the opposite axilla and across the chest to the back, passing between the injured arm and the trunk (Fig. 40). This band draws the arm backwards, and hence tends to correct the backward displacement of the inner end of the outer fragment.

The elbow is now supported and the downward displacement counteracted by a second strip of plaster, the middle of which contains a slit which is placed over the point of the elbow (which is



FIGS. 39, 40.—Sayre's method of treating fracture of the right clavicle. The strapping passing round the arm and chest draws the former to the side and backwards; that passing under the elbow and over the shoulder elevates the former and supports it (G. Coltart).

drawn well forwards), its ends being respectively carried forwards and backwards and uniting over the opposite shoulder, where they should be stitched together. A body roller may now be applied to give additional security.

In cases where the seat of the fracture is such that there is no displacement, the arm may be placed to the side, and the forearm being flexed across the chest, the limb is kept in position by a bandage.

FRACTURE OF THE SCAPULA

Fractures of the scapula are very rare and only produced by severe direct violence, occasioning considerable bruising and swelling of the soft structures and perhaps fracture of the ribs.

Fracture of the body usually occurs below the spine, but may implicate both fossæ. The fracture may be transverse, longitudinal, oblique, or stellate. The aceident can be deteeted by running the finger along the axillary and vertebral borders and comparing the two sides. Crepitus may be felt if the hand is plaeed over the bone while the patient's arm is moved, or the scapula may be grasped above and below and the fragments moved in opposite directions. When the arm is moved, the lower fragment does not follow the movements of the upper. Union results with deformity, a matter of no importanee as far as the utility of the limb is concerned.

Treatment.—The ehest should be encircled by broad strips of plaster, and the arm supported in a sling and eonfined by a body roller.

The acromion process is more eommonly broken than any other part of the bone, the aeeident resulting from falls or blows upon the shoulder.

Care must be taken not to mistake non-union or separation of the epiphysis for fraeture, an error which has often been made. The aeromial epiphysis normally joins between twenty-two and twenty-five years of age.

The faet of fracture is usually obvious; the arm is depressed, the shoulder flattened, and the line of the spine and acromion is interrupted. Crepitus will be obtained if the arm is raised.

The treatment is praetically that for fraetured elavicle, speeial eare being taken to draw the elbow upwards and give it efficient support.

Fracture of the coracoid process is a very rare aceident and is usually associated with fraeture of the elavicle or upper ribs. The fragment is drawn downwards and inwards by the pectoralis minor. The eoraeoid epiphysis, which normally unites at about the seventeenth year, is sometimes separated. The treatment eonsists in supporting the elbow by a sling and keeping the arm at rest.

Fracture of the neck of the scapula external to the root of the eoraeoid process is of doubtful oeeurrenee. The usual line of fracture of the neek passes behind the eoraeoid, which remains attaehed to the glenoid portion of the bone. This aceident is extremely rare and gives rise to slight lengthening of the arm. Crepitus may be felt if the arm be rotated while the surgeon grasps the point of the shoulder and the coraeoid proeess.

The treatment is the same as for fraeture of the acromion or coracoid process.

FRACTURES OF THE HUMERUS

Fractures of the upper end—Intracapsular fracture of the anatomical neck is always the result of direct violence, and is a rare accident. The upper fragment may lie loose in the joint, or may be impacted into, and cause fissuring of the lower—perhaps with separation of the great tuberosity. Union does not occur, since the detached head has no vascular supply; the head remains in the joint as a foreign body and the fractured surfaces become rounded off and eventually adapted. Inflammation and suppuration of the joint is very rare. In some cases the line of fracture may in part pass external to the capsule, which remains, in this situation, attached to the head and supplies it with blood. Under such circumstances ligamentous union may result. In impacted cases bony union may occur.

Signs.—There is considerable swelling and bruising about the shoulder, and pain and crepitus can be elicited if the arm be raised and rotated. If the fingers are placed in the axilla, the head, unless impaction has occurred, will be found not to follow the movements of the shaft. There is about one-third of an inch shortening;[1] the elbow is abducted and a slight depression below the acromion is present if there is not much swelling. In impacted fracture the diagnosis rests on the history of the accident and the shortening of the arm.

Fracture of the surgical neck is a very common accident from direct violence, and is sometimes caused by indirect violence through the elbow or hand.

The fracture is usually transverse, passing through the weakest part of the bone above the attachments of the latissimus dorsi and pectoralis major muscles (Fig. 41).

Impaction of the lower into the upper fragment may, though rarely does, occur.

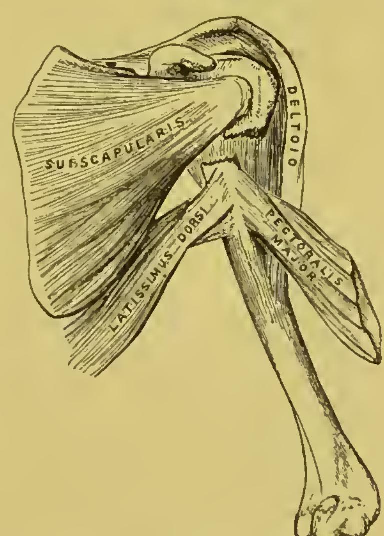


FIG. 41.—Fracture of the surgical neck of the humerus (Gray, after Hind).

Signs.—The upper fragment is abducted and rotated outwards

[1] The length of the arm is measured from the tip of the acromion to the external condyle.

by the muscles attached to the great tuberosity; the upper end of the lower fragment is drawn upwards and inwards towards the coracoid process by the muscles passing to it from the trunk, and forms a distinct prominence in the axilla. The axis of the shaft is thus directed upwards, forwards, and inwards, and there is about one inch shortening.

Increased mobility, crepitus, and pain—which may be considerable from irritation of the brachial plexus by the sharp end of the lower fragment—confirm the diagnosis. When the injury is due to direct violence, there is considerable bruising, and extravasation may result from damage to branches of the circumflex arteries.

If the fracture is impacted the diagnosis may be difficult, shortening then being the chief sign.

Fracture of the great tuberosity is a rare accident, and may be due to direct violence or to impaction of the fragments in fracture of the anatomical neck. The accident is perhaps most often due to muscular action, and is frequently associated with downward and forward dislocation of the head.

Signs.—The tuberosity is drawn upwards and outwards by the muscles attached to it, and a sulcus is present between it and the head of the bone, which is drawn inwards towards the coracoid process. The displacement of the fragment may be very slight, provided the ligamentous connections remain intact.

The breadth of the shoulder is much increased, and crepitus may be detected if the upper fragment be pushed into position and the arm is abducted and rotated.

FIG. 42.—Gutta-percha cap for the treatment of fractures of the upper end of the humerus and about the shoulder (Berkeley Hill).

Treatment of fractures of the upper end.—The treatment of these accidents is very similar, but as union can hardly be hoped for in fracture of the anatomical neck, rest need not be maintained for so long a time.

The application of an ice-bag, the arm being fixed to the side and supported by a small pillow, is necessary if there is much swelling.

The best appliance is a well-moulded gutta-percha shoulder cap reaching from the middle of the clavicle to the upper part of the forearm, which is flexed at a right angle (Fig. 42). The splint should be made to fit the outer, anterior, and posterior aspects of the limb, and in the middle of the arm

may completely encircle it. When the surgical neck is broken, a small axillary pad may be used to throw the upper end of the lower fragment outwards, but care must be taken that the axillary vein is not compressed.

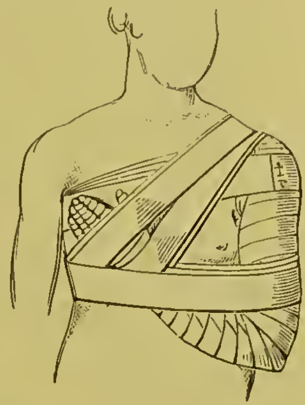


FIG. 43.—Fracture of the upper end of the humerus, showing the method of bandaging the arm when the shoulder cap (Fig. 42) has been applied (Berkeley Hill).

When the splint has been applied, the elbow must be drawn to the side and the lower part of the forearm supported by a sling (Fig. 43).

If a shoulder cap cannot be made, the arm may be immobilised by anterior, posterior, and external splints reaching from the shoulder to the elbow.

No attempt should be made to disengage impacted fragments.

Treatment should be kept up for a month or five weeks; at the end of the third the wrist and elbow joints should be daily moved to prevent subsequent stiffness.

Fractures of the shaft.—The shaft of the humerus is very often broken by direct violence, and occasionally by falls upon the elbow. The fracture is usually in the lower half of the bone, the line passing downwards and outwards with varying degrees of obliquity.

FIG. 44.—Fracture of the shaft of the humerus put up with an inside angular and outside splints (Berkeley Hill).

Signs.—There are the usual signs of fracture with over-riding of the fragments and proportional shortening. The actual displacement depends on the line of fracture, and upon which fragment carries the deltoid insertion, this muscle pulling it outwards and upwards. Thus, if the fracture is below the deltoid, the upper fragment is drawn outwards and rotated outwards, the lower passing inwards and upwards; if the deltoid is attached to the lower fragment, the displacement is more marked and less easily rectified.

Prognosis.—Union is complete in from four to six weeks, according to the age of the patient. Fibrous union and false joint are more often met with in the humerus than any other bone in the body.

Treatment.—The hand and forearm should be carefully band-

aged, and a rectangular splint, reaching from the axilla to the wrist, with two short splints (conveniently made of Gooch's splinting) reaching from the acromion to the elbow on the posterior and outer aspects of the arm, should be applied and carefully fixed in position, while an assistant makes careful and steady traction to reduce the longitudinal displacement. The lower part of the forearm is supported by a sling. Care must be taken that the splints, especially the inner one, are carefully padded, otherwise injurious pressure on the axillary vein or internal condyle may result.

FIG. 45.—T-shaped fracture of the lower end of the right humerus (Follin).

The splints will require readjustment in about fourteen days.

Fractures of the lower end.—The lower end of the humerus is usually broken by falls upon the elbow. This accident is not uncommon in children. The line of fracture is transverse, or passes obliquely upwards and backwards; sometimes the fracture is T-shaped into the joint (Fig. 45).

Signs.—The lower fragment, with the forearm, is drawn upwards and backwards by the triceps, the upper forming a prominence anteriorly above the bend of the elbow. The olecranon process retains its normal position to the condyles, a fact which, combined with increased mobility and crepitus, serves to distinguish the accident from backward dislocation of the radius and ulna.

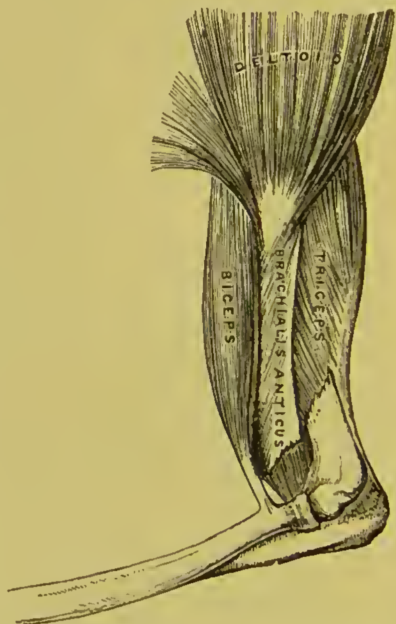


FIG. 46.—Fracture of the lower end of the humerus (Gray, after Hind).

If the fracture extend into the joint, acute synovitis with pain and swelling results, and may lead to some impairment of motion. In such cases it is not uncommon to find that the olecranon and coronoid fossæ become filled up by callus which prevents movement at the articulation. Under such circumstances forcible attempts at restoring movement are inadmissible, and may do considerable harm; passive motion, douching, and friction are all that is necessary, and,

as the callus becomes absorbed, movement will return. When the joint is involved the patient should be warned of the probable interference with its function.

Fracture of the condyles.—Falls upon the elbow, especially if causing dislocation, may break off one of the condyles, usually the inner. Pain and swelling are considerable, but the ligamentous, muscular, and periosteal connections prevent much or any displacement. Crepitus is felt if the forearm be moved, or if the outer condyle is broken by rotation of the radius.

Treatment.—Fractures of the humerus in the neighbourhood of the elbow joint sometimes offer great difficulties in diagnosis, on account of the great and rapid swelling, which is perhaps accompanied by synovitis. In such cases the arm should be laid upon a pillow, and the ice-bag be applied for a few days, and the employment of the Röntgen rays will prove useful.

The most convenient apparatus is an inside angular splint, reaching from the axilla to the wrist, the forearm being placed midway between pronation and supination and flexed to a right angle. An outside splint may be used if necessary. A gutta-percha splint is also useful.

Passive motion should be begun in three weeks, or earlier if the joint is involved. Union is complete in a month or five weeks.

In doubtful injuries of the elbow joint the forearm should be fully supinated and extended, it is then flexed to an acute angle and slung in such a position that the ball of the thumb rests against the opposite side of the neck. This position should be maintained for two or three weeks.

SEPARATION OF THE EPIPHYSES OF THE HUMERUS

Upper epiphysis.—The centres for the head and tuberosities unite at the fifth year to form one epiphysis, which joins the shaft at the twentieth.

Separation of the epiphysis is produced by the same causes, presents similar signs, and requires the same treatment, as fracture of the surgical neck. Crepitus is modified, the cartilaginous surfaces giving a dull, crackling sound. Great care should be taken to ensure perfect coaptation of the epiphysis and diaphysis in order that growth may be impaired as little as possible. If union does not occur, or if the damage has caused arrest of growth of the bone, the limb will be permanently stunted, the muscles atrophied and degenerated, and the usefulness of the arm much impaired. The length of the

humerus is chiefly dependent upon growth at the upper epiphysary line.

Lower epiphysis.—The centre for the internal condyle unites at the eighteenth year, and the rest of the lower epiphysis at the sixteenth. When the epiphysis is separated, it is drawn backwards and upwards. The accident resembles transverse fracture above the condyles, and like it must be diagnosed from dislocation backwards of the bones of the forearm (see p. 154). Arrest of growth at this end of the humerus is not so serious to the development of the limb as it is at the upper.

The treatment is that for fracture above the condyles (see p. 155).

FRACTURES OF THE FOREARM

Fracture of the shaft of one or both bones is usually the result of direct violence, but may also be due to falls upon the hand—although such an accident is more likely to cause fracture of the radius alone, the force being transmitted through that bone. Compound and greenstick fractures are by no means uncommon.

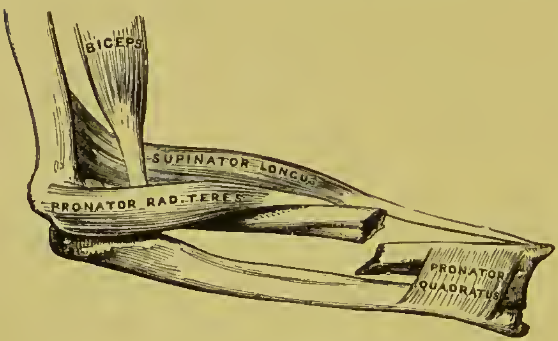


FIG. 47.—Fracture of the shaft of the radius (Gray, after Hind).

The shaft usually gives way in the lower half, the upper part being stronger and more protected by muscles. If both bones are broken, the line of fracture may be at the same level in each, but not uncommonly the radius gives way higher up than the ulna.

Signs.—The usual signs of fracture are present, and the accident is readily diagnosed. The degree of shortening, measured from the condyles of the humerus to the styloid process of the radius and ulna, depends on the obliquity of the fracture. In transverse fractures the longitudinal displacement is very slight.

Prognosis.—Union is complete in about a month. Non-union is occasionally seen. If the fracture is high up, and the forearm has not been kept fully supinated during treatment, union may occur at such an angle that complete supination becomes impossible. When both bones are broken, they may become united by a bridge of callus, and thus all movements of pronation and supination are lost.

Treatment is the same whether one or both bones are broken. The displacement is easily reduced by extension at the wrist, and the forearm is then placed in the supinated position and two straight splints are applied. The supinated position is strongly recommended by many authorities, but as it is irksome to the patient many surgeons prefer that of semi-pronation. The posterior splint should reach from the elbow to the heads of the metacarpal bones, the anterior one from the bend of the elbow to the wrist, and both must be a little wider than the forearm and well padded. It is often advised that a pad be placed along the line of the interosseous space to prevent a bridge of callus forming between the two bones, which would abolish the rotatory movement of the radius. This practice is to be condemned, since it cannot accomplish the purpose suggested, and has the serious disadvantage of possibly causing injurious pressure on the vessels, with swelling or even gangrene. When the splints have been secured in position by careful bandaging, the forearm is to be flexed to a right angle in order to relax the flexor muscles, and must be supported in a sling.

At the end of three weeks, or even earlier, the splints may be removed daily, to allow of gentle friction to the limb and passive motion; they may be discarded at the end of a month.

FRACTURES OF THE RADIUS

Fracture of the neck is a very rare accident, but may accompany dislocation at the elbow joint. Owing to the depth of this part of the bone and its protection by muscles, the diagnosis may present great difficulty. The upper end of the lower fragment is drawn forwards by the biceps, and the head of the bone is displaced slightly backwards.

Even in cases in which this accident has appeared certain, dissection has proved the falsity of the diagnosis; and Hamilton, referring to the difficulty, says: "Nor do I think, speaking only of the simple fracture, that it will ever be safe to declare positively that we have before us this accident, lest, as has happened many times before, in the final appeal to that court whose judgment waits until after death our decision should be reversed."

This decision can, however, now be arrived at by aid of the Röntgen rays.

Treatment.—The forearm must be fully flexed to relax the biceps muscle, and maintained in this position by an inside splint

for at least a month. Daily passive movement should be begun at the end of the third week.

Fracture of the lower end—Colles's fracture.—Colles's fracture is exceedingly common in old women from falls upon the outstretched hand. The accident may be bilateral.

Morbid anatomy.—The line of fracture is usually transverse, but there may be slight lateral obliquity, the line running upwards and inwards. Impaction of the lower into the upper fragment is common, and causes the peculiar deformity. The lower fragment is driven somewhat inwards, and hence the carpus and hand are carried to the

FIG. 48.—The bones of the forearm and hand from a man who many years before his death had sustained a Colles's fracture. *a*, lower fragment; *b*, upper (Follin).

radial side. In unimpacted cases the displacement is partly due to the contraction of the radial and thumb extensors, and of the supinator longus muscle. Hamilton considers that, in a large majority of cases, the deformity is due to relaxation, stretching, or more or less disruption of the radio-ulnar ligaments, which permits the hand to fall to the radial side by a simple rotatory movement over its articular surface; and he further states that he has seen this deformity in cases of fracture unaccompanied by displacement of the fragments, and even in severe sprains. The lower fragment is often comminuted, especially in old women whose bones are atrophied, and in these cases involvement of the wrist joint is common. The ulnar-carpal ligaments may be torn or the styloid process fractured.

Signs.—The diagnosis presents no difficulty. The hand is slightly arched and the fingers curved, the hand being carried to the radial side so that the styloid process of the ulna is prominent. The lower fragment forms a dorsal prominence with a depression above it, the upper a prominence on the anterior aspect with the depression below. Rotatory movements are lost and movement at the wrist is painful. rcpitus is present unless the fracture is impacted, in which case

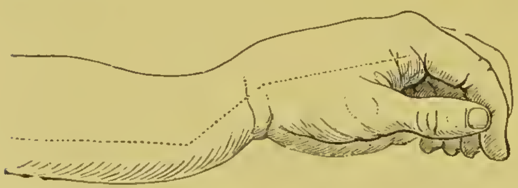


FIG. 49.—Colles's fracture of the radius showing the deformity occasioned by the backward displacement of the lower fragment (Follin).

it is necessarily absent and the deformity cannot be reduced without the employment of considerable force.

Inflammatory effusion may occur into and around the synovial tendon sheaths, and into the joint if the fracture implicates it.

Prognosis.—Union is usually complete in a month or five weeks, according to the age of the patient. Unless care be taken to allow free movement of the fingers during treatment and early passive motion at the wrist, much stiffness and pain will result, especially if the joint has been involved. The stiffness is doubtless due to the organisation of lymph in the synovial tendon sheaths. Pain about the wrist may remain for many months, and permanent deformity must be expected, the patient being warned of the fact.

Treatment.—If the fragments are impacted without great deformity no attempt should be made to disengage them unless the impaction is presumably slight, except in young patients, when the fragments should always be disimpacted if possible.

Carr's splint (Fig. 50) is the best and simplest apparatus, and has the great advantage of allowing free movement of the fingers during treatment, and hence in great measure obviates the painful stiffness which is so apt to result from their confinement.

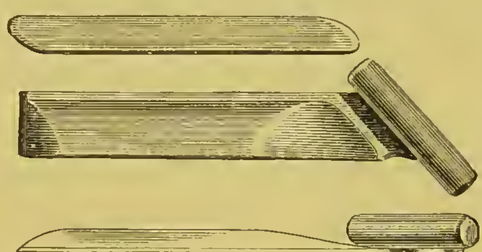


Fig. 50.—Carr's splint for Colles's fracture and fractures of the forearm (Berkeley Hill).

The cross-bar of the splint should lie opposite the knuckles, and the dorsal splint should reach a similar distance. If the fracture is impacted, the dorsal piece of the splint may be dispensed with.

Nélaton's pistol-splint is useful if the displacement to the radial side is very marked. This pistol-shaped splint is applied to the back of the forearm; when the handle has been bandaged to the hand, the upper end of the splint is drawn into position, and thus the hand is carried to the ulnar side. A straight, well-padded splint is then applied to the front of the forearm, reaching from the bend of the elbow to the lower end of the upper fragment, and the two splints are retained in position by a bandage.

Numerous other splints have been devised for the treatment of Colles's fracture, but those given suffice for all practical purposes.

At the end of ten days or so the splint should be removed daily to allow of passive motion, and all support can be dispensed with in about a month.

A course of cold douching, massage, and friction will do much to restore free and painless movement.

Separation of the lower radial epiphysis.—The lower epiphysis of the radius joins the shaft at about the twentieth year. If the epiphysis is separated, the deformity is similar to that of Colles's fracture; but according to R. Smith, the projection of the lower end of the shaft is more pronounced and less oblique.

The epiphysis retains its normal position to the carpus. If growth is interfered with as the result of this injury, the ulna becomes longer than the radius and tends to push the hand over to the radial side.

The **treatment** is that for Colles's fracture (p. 159).

FRACTURES OF THE ULNA

Fracture of the coronoid process occasionally complicates dislocation of the ulna backwards. The treatment consists in keeping the limb at rest on an inside splint in the flexed position, in order to relax the brachialis anticus. Passive motion may be begun during the third week, but great care must be taken not to break the callus.

FIG. 51.—Fibrous union after fracture of the olecranon, which has been drawn up by the triceps muscle (Fergusson).

Fracture of the olecranon process is due to direct violence when the elbow is flexed. This injury necessarily involves the joint, and is accompanied by considerable effusion into the cavity and the soft structures round it.

The diagnosis presents no difficulties if the case be seen soon after the accident, but later on the swelling may be so great that accurate examination is impossible.

If the ligamentous and tendinous expansions are completely torn across, the separated process is drawn upwards by the triceps (Fig. 51); the elbow is semiflexed, and voluntary extension is much impaired from loss of the triceps attachment. If, as is often the case, the ligamentous structures are not completely torn, the displacement is proportionately slight. Crepitus may be obtained by extension of the forearm, while the fragment is drawn downwards. The **olecranon epiphysis** joins the shaft at the fifteenth

year, before which time it may be accidentally separated. In some cases the epiphysis is never united.

Treatment.—Ligamentous union is the rule. If the fracture is compound, the fragments should be wired as in fracture of the patella. In simple cases the fragment should also be wired, provided perfect asepsis can be assured. In simple cases not submitted to operation, the olecranon should be drawn into position by strapping or by a bandage and pad, the figure-of-eight turn being used. The limb is fully extended and a gutta-percha splint, moulded to the limb and reaching from the upper third of the arm to the wrist, should be carefully adjusted. Rest must be maintained for at least a month, but very gentle passive motion may be begun during the third week, due care being taken not to use much force for fear of separating the process again.

If there is much swelling and synovitis present, an ice-bag must be continuously applied, the patient being confined to bed and the limb supported on a pillow. When the swelling has subsided, the fracture must be put up as described.

FRACTURE OF THE BONES OF THE HAND

The carpal bones are only broken by direct violence, and that very rarely. There is no displacement, in consequence of the intimate articulations and numerous ligamentous connections of the individual bones. The diagnosis is by no means easy, and is rendered more difficult by the great amount of swelling.

The treatment consists in rest for three weeks in a gutta-percha gauntlet, with passive motion at the end of ten days.

The metacarpal bones may be broken by direct violence, or by striking a heavy blow with the fist. One or more bones may give way. The line of fracture is usually about the middle or rather nearer the head of the bone. There is practically no displacement—pain, crepitus, and swelling being the only signs of the accident. Crepitus and pain are best elicited by pulling upon the finger.

Treatment.—The hand must be kept at rest for about three weeks in a gutta-percha gauntlet, or by means of plaster of Paris or liquid glass bandages, extending from the knuckles to the wrist; or the hand may be made to grasp a rolled bandage, or some similar object, and confined in this position by a bandage. The last method has the disadvantage of being very uncomfortable, and of confining the fingers. Carr's splint is useful and efficient.

The phalanges are sometimes broken by direct violence, those of the first row being much more frequently injured than the others. The line of fracture is transverse, and the accident may be compound or comminuted. The diagnosis is obvious, and treatment consists in applying a straight wooden, or moulded gutta-percha splint, to the dorsal aspect of the hand and fingers. Union is complete in two or three weeks.

Dislocations

DISLOCATIONS OF THE STERNAL END OF THE CLAVICLE

Varieties and causes.—Dislocation may be complete or partial, and the sternal end may be displaced **forwards, backwards,** or **upwards,** in order of frequency. These dislocations are produced by violence applied to the end of the shoulder from before, behind, or above, the direction of the violence determining that of the dislocation; thus force applied to the end of the shoulder anteriorly drives it backwards, and the sternal end of the clavicle forwards. Forcible lateral compression of the shoulders may also cause dislocation, especially in the backward direction.

Anatomy.—The ligaments are torn, but the rhomboid usually escapes, excepting in the upward dislocation. The interarticular cartilage is torn at one end, and may remain attached to the sternum or clavicle. In the backward and upward dislocations the head of the bone lies behind the inner head of the sterno-mastoid muscle, and may press upon the trachea.

Signs.—In all dislocations of the clavicle, the acromion process is approximated to the middle line, and the interclavicular notch is narrowed. The sternal end of the clavicle may be felt in its new position, and moves with the arm, giving rise to pain.

Dislocation forwards.—The sternal end is carried forwards and slightly downwards on the sternum, forming a distinct subcutaneous prominence. The point of the shoulder is directed slightly backwards. The clavicular head of the sterno-mastoid is drawn forwards, and is sharply defined.

Dislocation backwards is very rare. The end of the bone lies between the prominent sternal origin of the sterno-mastoid and the depressors of the hyoid bone, and the outline of the sternal articular facet may easily be defined. There may be signs of pressure on the trachea or subclavian artery (the pulse at the wrist

being lessened in volume), and these will be made more evident by drawing the shoulder forwards.

Dislocation upwards is the rarest form. The shoulder is slightly depressed, and the end of the bone is pushed up behind the sterno-mastoid, so that the distance between the clavicle and first rib is increased. The trachea may be compressed, and the sterno-mastoid is prominent.

Reduction may be easy, difficult, or impossible.

The surgeon stands behind the patient, grasps the shoulders, and forcibly approximates them posteriorly, with his knee pressed against the back if necessary. Pressure may be made against the displaced bone by an assistant in the upward or forward dislocation. In the backward displacement the arm must be drawn from the side, and at the same time the shoulder elevated and drawn backwards. When reduction has been effected, a pad should be placed in the axilla, the arm confined to the side, and the patient placed in the recumbent position for a few days. Complete rest of the arm is necessary for a month or six weeks.

Although it is usually easy to accomplish reduction, it is by no means so easy to maintain the bone in position and prevent recurrence of the dislocation.

Should this occur, the patient must be fitted with an apparatus calculated to draw the shoulders backwards, and this must be worn for at least six weeks.

If, in spite of all care, maintenance of position be impossible, the dislocation must remain unreduced; but very little inconvenience usually resulting, although the arm is less able to bear severe strain. If the trachea is pressed on in the backward or upward displacement, it will in time usually adapt itself to the changed condition of things, but should the pressure be of a serious nature, and should all efforts at rectifying the deformity fail, the end of the bone must be excised.

DISLOCATIONS OF THE SCAPULA (ACROMIAL END OF THE CLAVICLE)

Varieties and causes.—Dislocation downwards (acromial end of the clavicle upwards) is by far the most usual, and is due to blows or falls on the end of the shoulder, the force acting from above. The upward dislocation (acromial end downwards) is very rare, and is caused by violence acting from above on the outer end of the clavicle. In exceptional cases the acromial end of the clavicle has passed beneath the coracoid process.

Occasionally the clavicle is separated from both its sternal and acromial articulations.

Signs—**Dislocation downwards.**—The acromial end of the clavicle rides on the acromion, which is depressed, and is slightly nearer the middle line. There is a depression external to the prominence formed by the clavicle, and the nature of the accident is at once evident by comparison of the two shoulders. There is very little pain unless the arm be abducted.

Dislocation upwards.—The clavicle is depressed, and the acromion forms a prominence externally with a depression to its inner side. In both cases the movements of the scapula are limited and painful.

Reduction is easily effected by placing the knee against the back, and drawing the shoulders backwards, direct pressure being exerted on the clavicle if needful. Reduction may be facilitated by a pad in the axilla tending to throw the arm outwards. The upward displacement is readily retained in position; the scapula should be fixed by strapping, and the arm kept to the side, complete rest being observed for at least a month.

The downward dislocation is very easy to reduce, but very difficult to keep in position owing to the shallowness of the articular surfaces and the weight of the arm. An attempt may be made to keep the bones in apposition by placing a pad over the joint, and firmly strapping it on by a strap and buckle, passing over the shoulder and under the elbow, which should be flexed to a right angle, and supported in a trough splint. The band may be prevented slipping by a second one attached to it in front and behind, and passing under the opposite axilla. If this or any other form of retentive apparatus is used it must be worn for at least six weeks; but as the unreduced dislocation is productive of no harm, many patients would object to the treatment, which indeed frequently fails.

DISLOCATIONS OF THE HUMERUS

The humerus is more frequently dislocated than all other bones in the body taken together. This is due to the looseness of the capsule, the shallowness of the glenoid cavity, and the very free movements of the joint, placed as it is at the end of a long lever to which violence is so often applied. If the scapula were a fixed instead of a movable bone, dislocations at the shoulder would be still more common.

Varieties and causes.—The **subcoracoid** and **subglenoid**

dislocations are usually produced by violence applied to the outer side of the upper end of the bone in such a direction as to drive the head against the lower and anterior part of the capsule. Heavy falls on the elbow or hand when the limb is in a position of abduction will also occasion the accident. Muscular action alone, especially if the limb be abducted and fixed, is occasionally productive of dislocation. The subcoracoid dislocation, and its exaggerated form the **subclavicular**, are doubtless often consecutive to the subglenoid, the capsule being sufficiently ruptured to allow the head of the bone to be carried upwards and forwards by muscular contraction.

Subspinous dislocation is rare, and is caused by falls or blows on the advanced elbow, the head of the bone being displaced backwards.

Signs common to all forms.—In whatever direction the head of the humerus may be displaced, there are certain signs indicative of the occurrence of dislocation.

1. Immobility is more or less complete.

2. The axis of the limb is altered, and the elbow cannot be placed against the side without difficulty and much pain.

3. The patient is unable to touch the opposite shoulder, the top of the head, or to place the forearm behind his back.

4. The outline of the shoulder is altered, and the head may be felt in its new position.

5. The vertical circumference of the shoulder, measured round the axilla, is considerably increased.

6. The length of the arm, as measured from the tip of the acromion to the outer condyle of the humerus, is altered.

Subcoracoid and subclavicular dislocations.—The subcoracoid (Fig. 52, p. 166) is the most common form of dislocation; the subclavicular is rare, and is merely an exaggerated condition of the former.

Anatomy.—In subcoracoid displacement, the head of the humerus rests against the inner margin of the glenoid cavity or on the neck of the scapula. The rent in the capsule is large and situated at the lower and anterior part. The subscapularis muscle is ploughed up and lacerated, and its tendon may be completely ruptured. The deltoid is stretched and the supra-spinatus and infra-spinatus muscles may be stretched or torn, or the great tuberosity may be separated, thus allowing the head to go further forwards, as in the subclavicular dislocation. The axillary vessels and nerves are pushed forwards and inwards by the displaced head,

and are stretched and compressed. The circumflex nerve is specially liable to damage and may be torn.

Signs.—The acromion is prominent and there is a depression below it; the head of the bone will be felt beneath the clavicle, where it gives rise to a prominence replacing the normal slight depression between the deltoid and pectoralis major muscles. The elbow is abducted and carried slightly backwards, and the axis of the humerus (which is usually rotated inwards) is in a line with the middle of the clavicle. Shortening is very slight and there may be lengthening. Pain is often severe owing to the pressure on the cords of the brachial plexus.

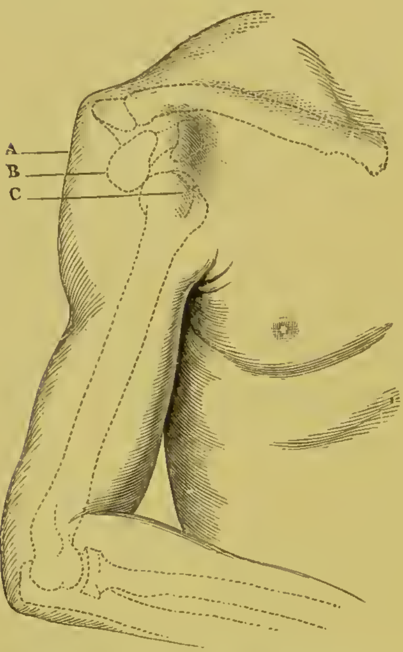


FIG. 52.—Subcoracoid dislocation of the humerus. *A*, flattening of the shoulder; *B*, glenoid cavity; *C*, head of the humerus (Follin).

Subglenoid dislocation is common, and is held by some to be more so than the subcoracoid. The head of the bone is, in some cases at least, prevented slipping upwards by the capsule, which encircles the anatomical neck.

Anatomy. — The inferior and inner part of the capsule is extensively ruptured, and the head of the bone lies below the glenoid cavity, in front of the long head of the triceps, and rests on the subscapularis. The long head of the biceps may be ruptured or displaced from the groove. The great tuberosity may be torn off, or the muscles attached to it lacerated. The deltoid and coraco-brachialis muscles are stretched or torn. The axillary vessels and nerves are stretched and compressed, and circulation through the axillary artery may be much diminished or even arrested. The posterior circumflex nerve is sometimes ruptured.

Signs.—The arm is in much the same position as in the subcoracoid dislocation, but the elbow is more abducted. In some cases abduction is extreme, and the arm may be almost at right angles with the trunk (*luxatio erecta*). The limb is lengthened by half an inch or more. Pain is severe, and the pulse at the wrist may be diminished in volume through compression of the artery; if the dislocation be not reduced, gangrene may occur from this

cause. The anterior fold of the axilla is lower than on the opposite side.

Subspinous dislocation is rare (Fig. 53). The head of the bone lies beneath the spine of the scapula, and at a variable distance behind the margin of the glenoid cavity. The capsule is usually much torn, and the subscapularis, coraco-brachialis, teres major, and long head of the biceps are stretched or lacerated.

Signs.—The elbow is advanced and the axis of the humerus, which is rotated in, passes downwards and forwards. The prominence formed by the head of the bone can be plainly seen in its new position, and there is a depression in front, just below and external to the coracoid process.

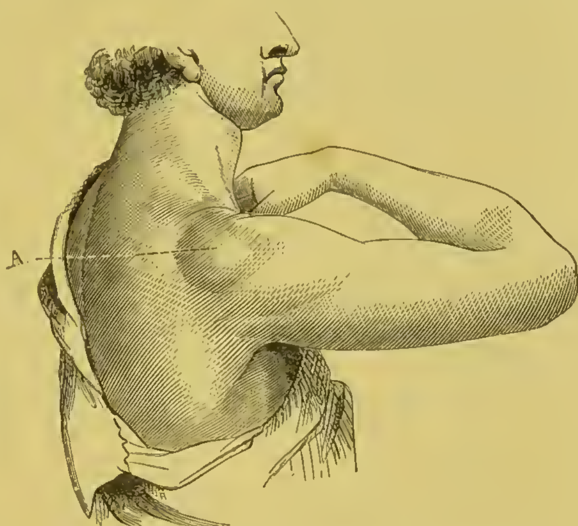


FIG. 53.—Subspinous dislocation of the humerus. *A*, prominence formed by the head of the humerus (Follin).

Prognosis in dislocations of the humerus.—If reduction be speedily effected, the torn structures soon unite and but little inconvenience is experienced, although the arm is weakened for a longer or shorter period. Subsequent dislocation from slight violence is not uncommon, and of this the patient should be duly warned. If the muscles have been much lacerated, or if passive motion has been neglected, considerable stiffness and impairment of motion may result. Paralysis and atrophy of muscles, especially the deltoid, may ensue on rupture or contusion of the nerves supplying them.

Reduction of these displacements is usually easily effected by manipulation, and may be attempted without an anæsthetic if the injury has been done within an hour or so. The following means may be employed, the scapula being fixed by an assistant grasping the acromion process.

Kocher's method.—The surgeon grasps the arm just above the elbow, which is flexed to a right angle; holding the forearm by the wrist, he slightly abducts the elbow, and rotates the humerus outwards, at the same time drawing the bone forwards, finally

the arm is carried across the chest, the humerus being rotated inwards.

The heel in the axilla (Fig. 54).—The patient being recumbent, the surgeon places his unbooted heel in the axilla, and grasping the wrist or the lower end of the humerus, makes steady traction in the line of the axis of the bone, at the same time carrying the limb towards the middle line of the body and pushing the upper end of the humerus into place with the foot. This method is usually readily successful.

The knee in the axilla.—This is the same in principle as the above, but is not so good, since the knee is too large, and the surgeon, standing behind the sitting patient, works at a disadvantage.

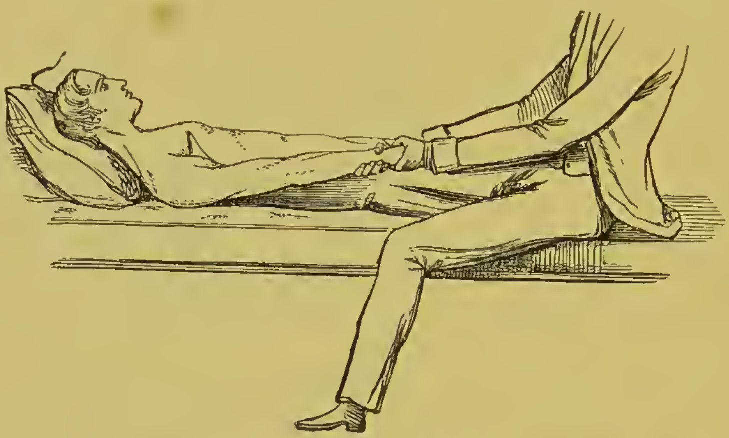


FIG. 54.—Method of reducing a dislocation at the shoulder by the foot in the axilla (Berkeley Hill).

Elevation of the limb.—The scapula is fixed by an assistant, the patient being recumbent. The surgeon grasps the lower end of the humerus, makes traction, and steadily raises the limb perpendicularly, thus relaxing the ligaments and muscles. This method is usually successful and very easy of performance.

After-treatment.—The arm must be bandaged to the side or placed in a trough splint, and complete rest maintained for two or three weeks according to the amount of damage presumably inflicted on the soft parts. Swelling and inflammation must be subdued by the ice-bag, and passive motion should be begun in about fourteen days. The patient must be warned against free use of the arm for three months at least, for fear of recurrence of the dislocation.

Old unreduced dislocations result in the formation of a more or less complete false joint, the situation of which depends upon that of the dislocation. The movements and use of the limb

may be in great measure restored. In some cases severe pain, atrophy of the muscles, or even gangrene may result from continued stretching of the nerves or interference with the blood supply through the artery.

If the dislocation is not more than three months old, reduction by manipulation or, failing this, by more forcible means (p. 123), should be attempted; after this date the question of trying to reduce the dislocation must be decided on the merits of the case, it being remembered that the bone and soft structures are atrophied, and that the muscles and other structures round the false joint are contracted and bound together; and hence that forcible attempts may entail fracture, damage to the soft parts with resulting suppuration, or even rupture of the artery or nerves.

If reduction be impossible, resection of the displaced head may be advisable either in consequence of the uselessness of the limb, or because there is severe pain or other ill consequences from pressure on the nervous trunks.

Compound dislocation of the humerus.—This is a very rare accident and is best treated by resection or amputation, according to the degree of laceration of the soft structures. If the artery or large nerve-trunks be torn, amputation is imperative.

DISPLACEMENT OR RUPTURE OF THE BICEPS TENDON (PARTIAL DISLOCATION OF THE HUMERUS)

Surgeons have described cases of partial displacement of the humerus in which it is supposed that the capsule is simply stretched but remains untorn. It is very questionable if such an accident be possible, and Hamilton and many others consider that such cases are really instances of displacement or rupture of the long head of the biceps. This tendon acts as an accessory ligament, antagonising those muscles which tend to draw the head of the humerus upwards and forwards. If the tendon be displaced or ruptured, these muscles are unopposed and will draw the bone in the direction indicated. The treatment consists in attempting to effect replacement of the tendon by rotatory movements of the arm, followed by complete rest, as in dislocations proper, for about three weeks.

DISLOCATIONS AT THE ELBOW JOINT

Varieties and causes.—One or both bones may be displaced anteriorly-posteriorly or laterally, or the two bones may pass in

opposite directions. Dislocations at the elbow are common accidents and are often seen in children, resulting in most cases from falls upon the hand, but sometimes from direct violence or twists of the forearm. Dislocation may be accompanied by fracture of the displaced bone or of the lower end of the humerus. The rapid onset of swelling may occasion considerable difficulty in diagnosis.

Dislocation of both bones backwards (Fig. 55) is the most usual displacement, and is sometimes complicated by fracture of the coronoid process. The radius and ulna maintain their normal relation to each other and pass upwards and backwards so that the coronoid process, if intact, lies in the olecranon fossa. The biceps and brachialis anticus muscles are stretched, as are also the vessels and nerves. The anterior and lateral ligaments are more or less torn, but the posterior may be intact and merely stretched.

Signs.—The patient supports the partially flexed forearm with the other hand. The olecranon lies above a line drawn between the two condyles of the humerus and forms a prominence behind which is increased by attempted flexion at the elbow. The head of the radius also forms a prominence behind, and the lower end of the humerus may be felt in front.

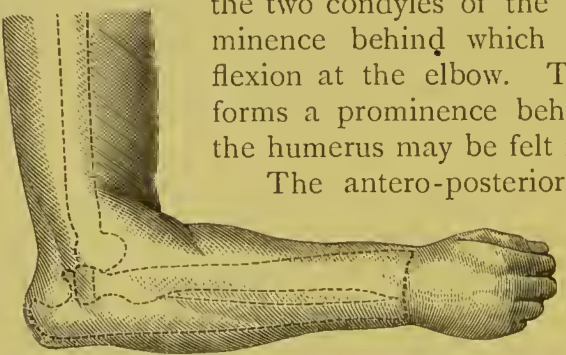


FIG. 55.—Backward dislocation of both bones of the forearm (Follin).

The antero-posterior diameter of the joint is increased, and the distance between the condyles of the humerus and styloid processes diminished. There is almost complete fixity, but slight lateral movement is possible. If the coronoid process be broken there is crepitus, and movement in the antero-posterior direction is possible.

Dislocation of both bones forwards is a very rare accident, and is complicated by fracture of the olecranon process; it is produced by great violence of a twisting or wrenching character. The forearm is flexed and lengthened and the condyles form a marked prominence posteriorly; the olecranon is separated from the rest of the ulna.

Dislocation of both bones laterally may result from inexpert endeavours to reduce the backward dislocation; or, if primarily produced, is due to violence acting laterally on the upper end of the forearm or lower end of the humerus while the forearm is fixed.

The outward displacement is the more usual, the inward being very rare. These dislocations are incomplete and the bones pass in a backward as well as a lateral direction.

The forearm is slightly flexed, pronated, and immobile. The breadth of the elbow is much increased, and the condyle of the humerus on the side opposite to the dislocation is very prominent, with a depression below; the opposite condyle is more or less concealed. The dislocation inwards may be accompanied by contusion or laceration of the ulnar nerve.

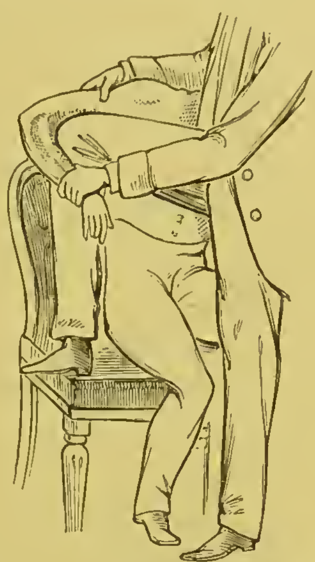


FIG. 56.—Method of reducing dislocation backwards of the bones of the forearm (Berkeley Hill).

Dislocation of the radius forwards and ulna backwards is very rare.

Reduction.—Dislocation backwards is usually readily reduced without anæsthesia. The patient being seated in a chair, the surgeon places his foot upon it, presses his knee against the front of the upper end of the forearm bones, and by backward pressure disengages them from the humerus. The latter is grasped by one hand and the wrist by the other, and traction is made at the wrist while the forearm is forcibly and steadily flexed. In the lateral displacements the same manœuvres are practised, accompanied by lateral pressure on the forearm bones.

If difficulty be experienced in effecting reduction by the means described, direct downward extension of the forearm may be successful.

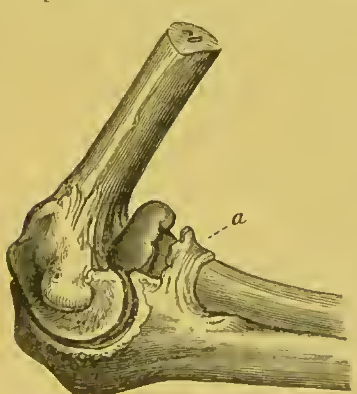


FIG. 57.—Forward dislocation of the head of the radius. *a*, orbicular ligament (Follin).

After-treatment.—The limb should be supported by a sling or placed in a trough splint for two or three weeks, gentle passive motions of flexion and extension, supination, and pronation being practised at the end of ten days. If there is much swelling an ice-bag should be applied for a few days.

Dislocation of the radius forwards (Fig. 57) is occasioned by a direct blow on the bone from behind, a fall on the pronated hand, or a sudden twist of the forearm. The head of the bone passes forwards and outwards, the

anterior, external lateral, and orbicular ligaments being more or less lacerated, and the external condyle occasionally fractured. The head of the bone may also pass *backwards* or *outwards*, but these dislocations are very rare. Sometimes these displacements are incomplete.

Signs.—The head of the bone forms a prominence in front, which moves with pronation and supination, but it cannot be felt in the normal situation. The measurement from the external condyle to the styloid process of the radius is diminished. The forearm is slightly flexed and pronated, and full flexion or extension is impossible.

Reduction may be impossible, or if achieved, the head of the bone may again slip out. The forearm must be extended downwards, while counter-extension is made at the lower end of the humerus; at the same time the surgeon endeavours, by direct pressure on the head of the bone, to force it into position.

If reduction is accomplished, the forearm must be flexed to relax the biceps tendon, otherwise this may pull the head of the bone out again. Rest must be maintained for a month or six weeks, passive motion being used at the end of a fortnight.

Unreduced dislocation may be successfully treated by excision of the radial head, but this should not be done at once if attempts to reduce a recent displacement fail, some interval being advisable for healing of the lacerated structures.

Dislocation of the ulna backwards with fracture of the coronoid process has been occasionally met with, but the accident is of great rarity. The signs are similar to those of dislocation of both bones backwards, but the head of the radius can be felt in its normal position.

DISLOCATIONS AT THE WRIST

Causes and varieties.—Dislocations at the wrist are extremely rare, and are occasioned by falls on the palm or dorsum of the hand or by violent twists. Dislocation backwards is the more usual, the forward displacement having been recorded only a few times.

The injury is accompanied by rupture of the ligaments, and the tendons, vessels, and nerves are stretched, torn, or compressed; it is frequently compound.

Signs.—The relation between the carpus and the styloid processes is altered, and thus differs from fracture of the lower end

of the radius and ulna. In the backward displacement the carpus forms a dorsal prominence, above which is a depression; anteriorly the lower ends of the radius and ulna and the styloid processes are well defined. The reverse would be the case in the forward dislocation.

Reduction.—The surgeon seizes the patient's hand as if about to shake hands, and holds the forearm above the wrist. Slight extension is then made on the hand and the carpus is pressed into position. Lateral movements sometimes aid reduction.

Complete rest and the ice-bag are necessary for about ten days.

If the accident be compound, amputation is usually necessary, owing to the damage inflicted on the soft structures.

DISLOCATIONS OF THE CARPAL BONES

Of these the os magnum is most commonly displaced backwards, the accident happening from falls on the hand. The bone may usually be readily pressed into position.

DISLOCATIONS OF THE METACARPAL BONES

The first metacarpal is most usually displaced in the forward or backward direction. The accident is due to a fall or to direct violence, as in fighting. The diagnosis is easy, the displaced bone being readily felt. Pressure on the base of the bone during moderate extension will easily effect reduction.

DISLOCATIONS OF THE FIRST PHALANGES

Causes and varieties.—The first phalanx of the thumb is the one usually dislocated; those of the fingers, especially the middle and ring, being rarely displaced. Dislocation backwards is produced by falls upon the thumb; the forward displacement is very rare, and is due to force applied to the dorsum of the flexed phalanx, as in fighting.

Signs (Fig. 58, p. 174).—The head of the metacarpal bone forms a decided prominence in the palm of the hand; the displaced phalanx is forced backwards, forming an angle with the metacarpal bone, and the second phalanx is flexed. In the forward dislocation the head of the metacarpal projects backwards.

Reduction may be difficult, partly because of the shortness of

the lever, and partly owing to the resistance offered by the button-holing of the head of the bone between the lateral ligaments and the tension of the two heads of the flexor brevis pollicis and other short muscles inserted into it. According to some, reduction is sometimes prevented by the torn anterior ligament slipping between the articular surfaces.

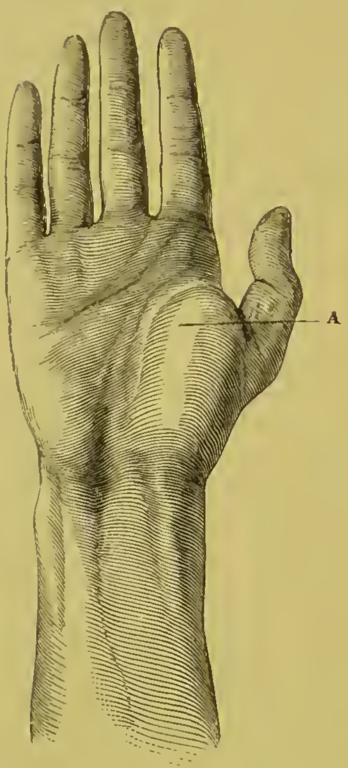


FIG. 58.—Backward dislocation of the thumb at the metacarpo-phalangeal joint. *A*, prominence formed by the head of the metacarpal bone (Follin).

The thumb should be seized, hyper-extended, and then sharply flexed. The length of the lever may be increased by firmly bandaging the phalanges to a narrow wooden splint, or use may be made of any of the ingenious contrivances which have been designed for this special purpose. If all attempts fail, the lateral ligaments must be divided subcutaneously, since it is to them the chief difficulty is due.

The forward dislocation is reduced by forced flexion followed by extension.

Dislocation of the first phalanx of a finger is precisely similar to that of the thumb.

DISLOCATIONS OF THE SECOND AND THIRD PHALANGES

The terminal phalanx is most usually displaced, and that of the thumb more often than that of any other finger. The dislocation may be backward or forward and is often compound. Reduction is effected by hyper-extension in the backward, and hyper-flexion in the forward dislocation.

Dislocations of the fingers must be treated by rest for a week or ten days.

CHAPTER X

INJURIES OF THE LOWER EXTREMITY

INJURIES of the lower limb are less common but more serious than those of the upper, which they resemble in all points; they are to be treated on the same lines.

A **gall of the heel** from an improperly fitting boot is very common, and unless kept clean may lead to lymphangeitis. The only treatment necessary is the avoidance of pressure and friction, with the application of some simple dressing such as boracic acid ointment.

In **crushes of the foot** necessitating amputation as much must be saved as possible, and the surgeon when operating should treat the foot as a whole rather than plan his amputation with regard to any particular articulation (see p. 224).

Wounds of the sole often give rise to much trouble, especially if any septic foreign body has become embedded in it. They must be treated on ordinary principles.

Rupture of muscles and tendons.—The quadriceps may be ruptured above or below the patella, the signs resembling transverse fracture of that bone. The hamstrings and calf-muscles may be lacerated or ruptured, and the adductors are sometimes torn in riding. These accidents are best treated by position and firm bandaging or strapping to ensure relaxation of the torn muscle and complete rest.

The tendo Achillis is occasionally ruptured and may be treated by plaster of Paris and flexion of the knee. Any tendons which may be divided in an open wound should be at once sutured.

Sprained ankle is a very common accident, resulting from sudden twists, especially if the toes are fixed, as in catching the foot in a hole. The damage done may be considerable and may

lead to permanent weakening of the joint if the ligaments have been lacerated. If severe, the accident may be difficult to diagnose from fracture at the ankle joint until all swelling has disappeared under the use of the ice-bag. As the pain and swelling subside assiduous douching and massage must be resorted to, or else permanent stiffness may result. The patient must not be allowed to use the joint until he can do so without pain, and an elastic support should be worn for some months.

Sprains of the knee are less common than those of the ankle, but are often more serious and lead to acute synovitis; even when slight, they are sometimes succeeded by white swelling.

Bruising about the hip sometimes causes much rigidity and pain, the limb assuming the position of dislocation. If there is any doubt about the diagnosis an anæsthetic should be given. The treatment consists in rest and massage.

Fractures

FRACTURES OF THE FEMUR

Fractures of the upper end—Intracapsular fracture of the neck is essentially an accident of advancing life; it is usually met with in women over fifty as the result of slight indirect violence applied to the foot, such as tripping up or catching the toes under the carpet. In many cases so slight is the force producing the injury that the accident may almost be regarded as spontaneous and consequent on the senile atrophy and thinning of the neck of the bone.

The fracture is entirely within the capsule, usually close to the head where the neck is weakest. Impaction occasionally occurs, but is rare owing to the indirect nature of the violence. The detached head is held only by the ligamentum teres, through which it gets its blood supply.

Signs.—The buttock is flattened, and the great trochanter, which on rotation of the shaft moves in a diminished circle, is approximated to the iliac crest. The limb, shortened by about half an inch or a little more, is semi-flexed at the knee, everted, helpless, and in the position of natural rest; the patient cannot raise it. Inversion is sometimes present, and is presumably due to temporary paralysis of the external rotators through injury.

Pain is usually slight and crepitus may be very indistinct; it is

best obtained by making traction on the thigh to reduce the shortening and then rotating inwards. The trochanter will be found to be above Nélaton's line. Unless great care be taken it is quite possible to mistake a case of osteo-arthritis, especially if associated with absorption of the neck of the femur (Fig. 59) and in which an injury has been sustained, for one of intracapsular fracture. The shortening in either case would be almost the same, and in both there may be a sensation of ill-defined crepitus.

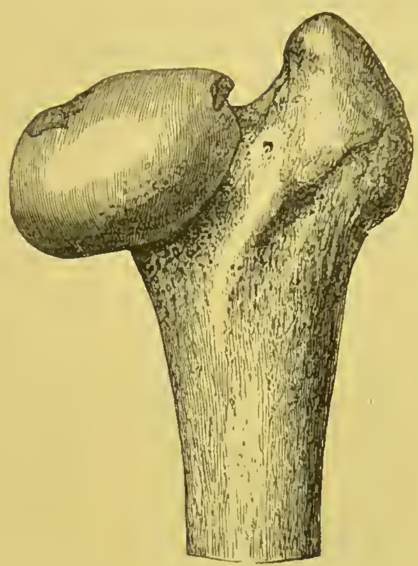


FIG. 59.—Interstitial absorption of the neck of the femur, from a specimen in the Westminster Hospital Museum (Holmes, *System of Surgery*).

Prognosis.—Intracapsular fractures of the neck either fail to unite or do so by fibrous tissue; bony union cannot be expected owing to the slight vascularity of the upper fragment and the patient's age. Permanent shortening and lameness naturally result. Hypostatic congestion, pneumonia, and bed-sores are to be feared if the patient is confined too long to bed in the dorsal position, especially if there be chronic bronchitis or cardiac insufficiency.

FIG. 60.—Extracapsular impacted fracture of the neck of the femur, with separation of the trochanter, from a specimen in the Westminster Hospital Museum, No. 89 (Holmes, *System of Surgery*).

Treatment.—For the first week or ten days the patient should be confined to bed and the fracture treated by weight extension or Liston's long splint; but should lung complications supervene, the patient must be propped up in bed at once in view of the above-mentioned dangers. At the end of this time a leather or poroplastic casing or a starch bandage

should be fitted to the pelvis and thigh, and the patient be allowed to get about on crutches.

Extracapsular fracture is most common in active adult life as the result of severe direct violence to the upper end of the femur; it sometimes occurs in old people from indirect or slight direct violence. In most cases the line of fracture passes through the neck, within the capsule in front, so that in this situation the joint is involved. In consequence of the direct nature of the violence the upper fragment is frequently if not always impacted into the lower (Fig. 60, p. 177). The impaction may severely comminute the upper end of the lower fragment, and may be very firm or so slight (especially if there is great comminution) that the fragments become readily disengaged during examination of the limb or by voluntary movements of the patient.

FIG. 61.—Fracture of the upper third of the shaft of the femur (Gray, after Hind).

Signs.—There is considerable contusion and swelling about the hip, but in other respects the signs are practically the same as those of the intracapsular injury. There is, however, more shortening—sometimes as much as two or three inches—and crepitus is more distinct unless the fracture be impacted. Impacted fracture may present some difficulty of diagnosis, for the patient may be able to stand or even walk; crepitus is absent and shortening may be slight.

Prognosis.—Bony union occurs in from six to eight weeks, a good deal of callus being thrown out. The patient should be warned that shortening and lameness will be permanent.

Treatment.—If there be very much bruising and swelling about the hip, the limb should be fixed by weight extension and sand-bags, and evaporating lotions or ice should be applied to the parts for a few days. The long splint is the best permanent apparatus, the patient being kept at rest for six or eight weeks. If the fracture is impacted no attempt to disengage the

fragments should be made, but the patient may be allowed up on crutches in about a month, the pelvis and thigh being encased in a poroplastic splint or starch bandage.

Fracture of the great trochanter is most frequently caused by the force of impaction of the upper into the lower fragment in extra-capsular fracture, but may also occur as the result of direct violence. The epiphysis which unites at eighteen is occasionally separated by violence (Fig. 31, p. 114). The separated trochanter is drawn upwards and backwards by the glutei, but displacement is not marked unless all periosteal and fibrous connections are lacerated.

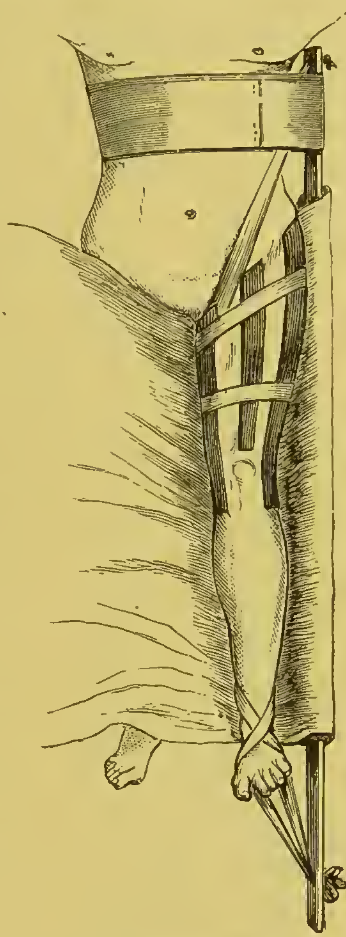


Fig. 62.—The Scotch sheet for fractured femur. It is completed by drawing the sheet over the limb and fixing it to the splint with drawing pins (Berkeley Hill).

Fracture of the shaft (Fig. 61).—Fracture of the femoral shaft is a common accident; it often occurs in children, and is usually caused by indirect violence.

The plane of fracture is slightly oblique from above downwards, forwards, and outwards, and is usually in the middle third. The upper fragment is flexed by the ilio-psoas, and rotated outwards by the pyriformis and external rotators; the degree of flexion is sometimes great when the fracture is high up. The lower fragment is drawn upwards, backwards, and inwards by the hamstrings and adductors, and rotated outwards by the adductors and the weight of the limb. Longitudinal deformity with proportionate shortening is sometimes very pronounced.

The diagnosis of this injury presents no difficulty, the usual signs of fracture being conspicuous.

Treatment.—In adults Liston's long splint and the Scotch sheet will usually be found to be the most convenient and efficient apparatus, the use of the sheet allowing the surgeon to expose the seat of fracture at any time without disturbance of the limb (Fig. 62). The splint should reach from the level of the nipple to six inches below the heel. Short splints, conveniently made of Gooch's

splinting, and reaching from the groin to the knee, should be placed on the anterior, inner, and posterior aspects of the limb, and, when the deformity has been reduced, fixed in position by two webbing straps with buckles. The use of these splints is essential, the long splint only acting as an external support, and maintaining the length of the limb. All the splints must be carefully padded, especially below, so that no pressure is exerted on the condyles.

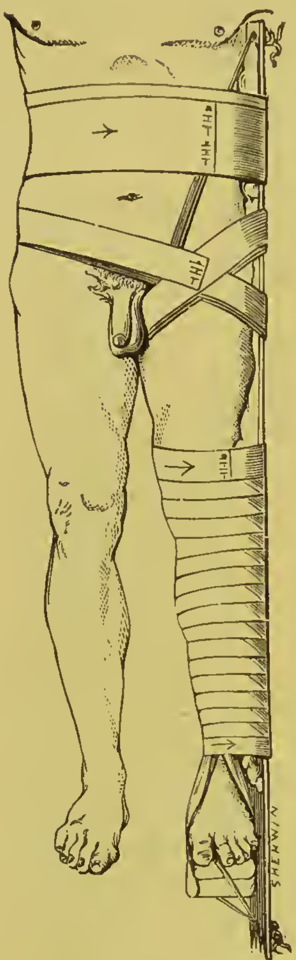


FIG. 63.—The long splint, with elastic stirrup extension at the foot. The bandage is carried up to the seat of fracture (Berkeley Hill).

When all is ready, an assistant makes traction on the limb to reduce the deformity, and, the short splints being adjusted, the surgeon fixes the foot to the lower part of the long splint, and then tightens the perineal band; the upper part of the splint is kept in position by a few turns of a broad bandage round the chest. Extension may also be obtained by raising the lower end of the bed on blocks, and applying elastic extension to the limb, the perineal band being discarded. The sheet, previously fixed to the splint, is passed behind the limb, drawn up on the inner side, and secured to the anterior border of the splint by drawing pins. Thomas's knee splint, with four short splints along the thigh, is also a very convenient method of treatment, and enables the patient to move about on crutches in a fortnight or three weeks.

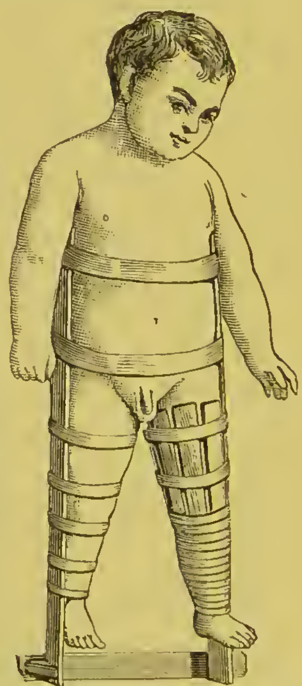


FIG. 64.—Hamilton's splint (Berkeley Hill).

If there is much tilting forwards of the upper fragment, the double inclined plane is very useful, the bent position of the knee and hip causing relaxation of the muscles.

Fracture of the shaft in children is best treated by Hamilton's

splint, which is practically a couple of Liston's splints united below by a cross piece (Fig. 64). This completely fixes the pelvis and lower limbs, while the child can be moved about for purposes of cleanliness without fear of disturbing the fragments. Before Hamilton's splint is applied, the three short splints should be put on as already described, and if there be much over-riding of the fragments a perineal band may be used; but this is not often required, since the periosteum usually remains intact, and hence displacement is but slight.

Whatever form of appliance is used in the treatment of fractures of the shaft, it should be kept on for a month, after which a light plaster casing or starch bandage may be applied and the patient allowed up on crutches; but no weight must be put on the limb for fully two months.

The patient should be warned that a certain amount—usually about half an inch—of permanent shortening will result. Such shortening is not appreciable in children.

Fractures of the lower end.—Fracture immediately above the condyles is usually more or less oblique (Fig. 65), but may be transverse (Fig. 66, p. 182). In some cases it is T-shaped into the joint, or one condyle may be separated from the rest of the bone. These accidents are caused by direct injury or by heavy falls upon the knee, in which case the upper fragment may be impacted into and severely comminute the lower.

FIG. 65.—Oblique fracture of the lower third of the femur, the line passing downwards and forwards (Holmes, *System of Surgery*).

Signs.—In fracture above the condyles the upper fragment is drawn somewhat forwards, and perhaps slightly inwards, while the lower one is flexed into the popliteal space by the gastrocnemius. Occasionally the sharp upper end of the lower fragment wounds the popliteal artery. Shortening, mobility, and crepitus are present, unless the fracture is impacted. If the knee joint is involved, there is con-

siderable pain and swelling from effusion of blood and synovial fluid. Separation of a condyle increases the breadth of the lower end of the bone.

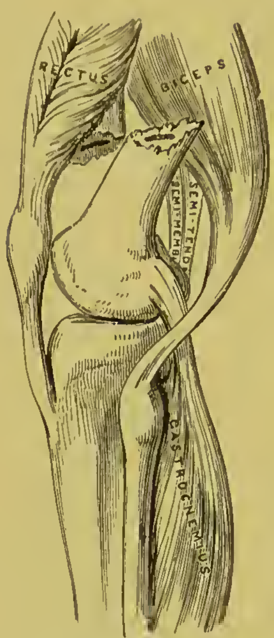


FIG. 66.—Supra-condylar fracture of the femur (Gray, after Hind).

Treatment.—Owing to the flexion of the lower end, there is considerable difficulty in restoring and keeping the fragments in position. The double inclined plane, or M'Intyre's splint, are the best appliances, as they ensure apposition of the fragments. If the contraction of the gastrocnemius is very strong, and cannot be overcome by position, tenotomy of the tendo Achillis may be advisable, but is rarely required. If the joint is involved, and there is much distension of the capsule, aspiration may be practised, and the ice-bag must be employed for a few days. The patient must be warned, in case of injury to the joint, that stiffness may last for many months or permanently. Massage and gentle passive motion must be begun at the end of two or three weeks.

Separation of the lower epiphysis of the femur (Fig. 31, p. 114).—The epiphysis joins the shaft at the twentieth year. It is occasionally separated as the result of violence, usually of a twisting character. The epiphysis, contrary to what happens in pathological separation, is generally displaced forwards, the diaphysis projecting in the ham and occasionally protruding through the skin. When reduction has been accomplished, the limb should be kept at rest, on a back splint or double inclined plane, for a month or five weeks.

FRACTURES OF THE PATELLA

Varieties and causes.—Transverse fracture is due to muscular action. At the time of the accident the knee is slightly bent, and the patella resting against the lower end of the femur. The patient having taken a false step, suddenly contracts the quadriceps and thus the patella, fixed

FIG. 67.—Transverse fracture of the patella from muscular action (Fergusson).

FIG. 68.—Stellate fracture of the patella from direct violence; bony union has occurred (Fergusson).

below by the tendon, is snapped across the femur. This accident is most common in middle adult life.

FIG. 69.—Transverse fracture of the patella (Gray, after Hind).

Stellate, comminuted, and compound fractures are due to direct violence.

Morbid anatomy.—The knee joint is necessarily involved. In transverse fracture the aponeurotic expansions are torn, and hence there is wide separation of the fragments, increased by extravasation and effusion into the joint. Portions of the torn ligamentous structures may be interposed between the fragments. Fracture by direct violence is not accompanied by rupture of the fascia, and hence the fragments remain in apposition. The patella bursa may be ruptured.

FIG. 70.—Fracture of the patella united by ligamentous tissue, from a specimen in the Westminster Hospital Museum, No. 100 (Holmes, *System of Surgery*).

Signs.—In transverse fracture the patient often attributes the accident to a fall, although this is consequent on and not causative of the injury. The knee is semiflexed, and cannot be extended; the condyles are clearly outlined, and form prominences beneath the skin; and the fragments are more or less widely separated. In a very short time synovial effusion added to the extravasated blood, causes much distension of the capsule, giving great pain, and masking the outline of the lower end of the femur. Crepitus is only obtained if the knee be extended, the thigh flexed, and the upper fragment brought down by pressure from above.

In cases of stellate fracture crepitus is best obtained by placing the fingers of one hand over the bone, and pressing its circumference with the other. There is no unnatural prominence of the condyles.

Prognosis. — Stellate fractures unite by bone (Fig. 68), but osseous union rarely, if ever, occurs after transverse fracture. In such cases the uniting bond of fibrous tissue may be so dense and intimate that little impairment of the joint results, and

one might suppose that bony union had really occurred. Unless accurate apposition of the fragments has been secured, and complete rest given for at least three months, the fibrous link may be very thin and weak, and as much as six inches in length (Fig. 70, p. 183); thus the joint is left unprotected and practically useless.

If flexion and extension movements are permitted too early (assuming the fragments not to have been wired), even good fibrous union may become impaired, the tissue gradually yielding and elongating. If pressure has not been applied in the right direction, considerable tilting of the fragments may result, the broken surfaces looking forwards.

However intimate the union in transverse fractures, there is always some impairment of movement and stiffness about the joint, flexion being chiefly affected. The stiffness gradually diminishes with time.

After fracture of the patella the joint is liable to transient mild attacks of effusion accompanied by pain.

The plan of immediately wiring a broken patella materially assists firm union, and not only gives a better result than does treatment without operation, but materially shortens convalescence.

Treatment.—If for any reason operative treatment is decided against, the main indications are—

(1) To empty the joint by aspiration;

(2) To relax the quadriceps and bring the fragments into as good position as possible; and

(3) To immobilise the joint for at least two months.

After aspiration the limb may be placed on a back splint and the ice-bag be applied for a few days. Of the numerous contrivances employed to approximate and immobilise the fragments, none are entirely satisfactory, but the following method is perhaps the best:—

The fragments are drawn together by strips of plaster. A pad of lint is placed against the upper edge of the upper fragment, and over this a piece of strapping is drawn tightly and passed downwards across the popliteal space. The lower fragment is similarly treated, the strapping passing upward, so that the two fragments are drawn together. The thigh is slightly flexed, and the knee is now fixed in the extended position in a plaster casing, which is kept on for two months, or it may be fixed to a back-splint (Fig. 71) for the first two or three weeks.

Operative treatment in recent cases.—Much difference of opinion still exists as to the advisability of resorting to operation in

recent simple fractures of the patella, while all are agreed as to its performance in compound cases. No doubt excellent results are obtainable without operation, but convalescence is much longer.

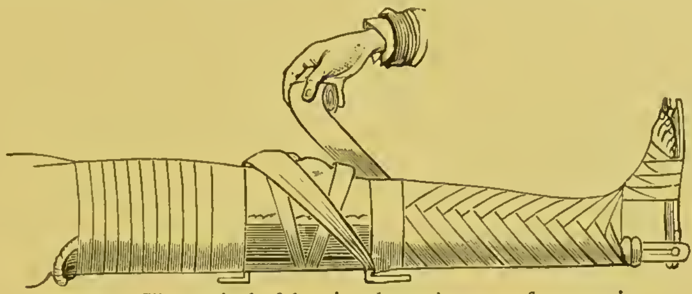


Fig. 71.—The method of drawing down the upper fragment in a case of fractured patella (Berkeley Hill).

Unless strict asepsis can be assured no operation is justifiable, nor should one be undertaken if the patient be not in good health.

Given the above essential conditions, operative treatment is the readiest means of securing a good result. The best method is that introduced by Mr. Barker, provided it can be carried out within a few hours of the accident. The operation is very simple, and is thus performed :—

The fragments are first rubbed together to clear the broken surfaces of any blood-clot or ligamentous bands. Steadying the lower fragment, the surgeon passes a narrow knife through the centre of the ligamentum patellæ just below the apex of the bone, and thus opens the joint, the skin wound being about three-quarters of an inch long. Through this opening a needle, specially made to carry silver wire the size of a No. 1 English catheter, is passed behind both fragments, and pierces the quadriceps tendon close to the upper margin of the upper fragment. When the needle is felt beneath the skin in this situation, it is cut down upon through

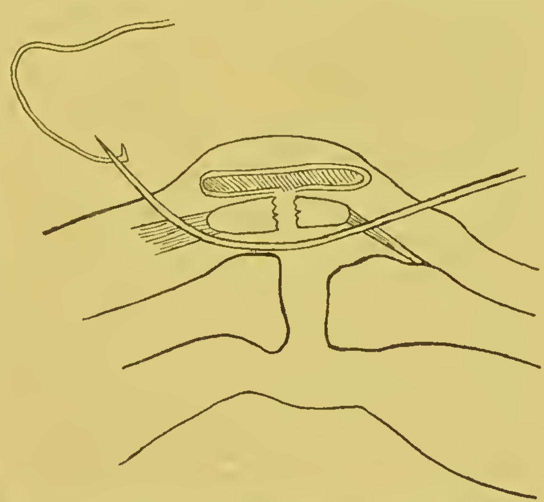


Fig. 72.—Diagram of Barker's method for immediate wiring of the patella. First stage: The needle is passed from below, through the tendon, beneath the fragments, and out through the skin above, and is then threaded with silver wire (G. Coltart).

a small incision and threaded (Fig. 72, p. 185), then withdrawn and unthreaded. It is now passed through the same openings but in front of the patella, threaded with the other end of the wire, again withdrawn and unthreaded (Fig. 73). The wire thus encircles the bone from above downwards, both ends coming out of the lower opening. The blood is now squeezed out of the joint through the lower wound, and the fragments are again rubbed together.

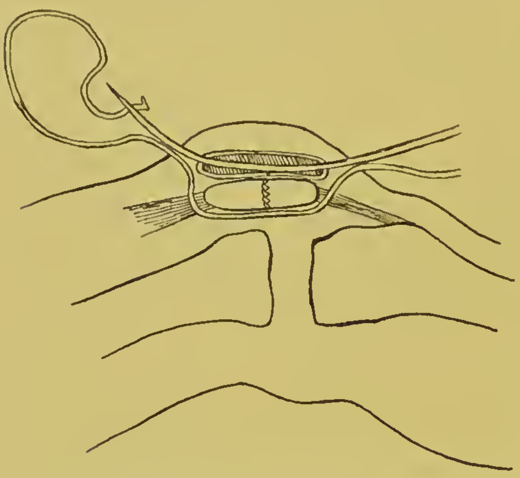


FIG. 73.—Diagram of Barker's method for immediate wiring of the patella. Second stage: The wire having been drawn beneath the fragments as shown in Fig. 72, the needle is again passed from below up, but in front of tne fragments and out by the same opening as before; it is threaded and withdrawn. The ends are twisted and embedded in the tendo patella (G. Coltart).

Each end of the wire is fixed to a short steel bar in order that it may be more easily drawn upon and twisted. The ends of the wire are crossed, so that the portion passing behind the fragments is drawn upwards, and that in front downwards. The fragments are accurately approximated and the wire drawn tight and trebly twisted. The end of the wire is embedded beneath the skin in the substance of the tendon and the two wounds are closed. A dry antiseptic dressing is applied, and the patient is allowed to move his leg next day, provided he is free from pain. A splint is unnecessary unless the patient is very restless. Slight flexion and movement of the joint is practised daily to prevent stiffness and muscular atrophy. Massage is begun on the day after the operation, and employed daily for a fortnight, with the object of increasing nutrition and favouring the absorption of any blood which may still be present in the joint. In most cases the patient is able to walk about in six or eight weeks, and very firm, apparently bony, union occurs; moreover, there is practically no pain or stiffness about the limb and the buried wire does no harm.

This method is certainly preferable to the open one, as the risk is reduced to a minimum, the operation is quickly performed, and the small wounds, healing rapidly, allow of passive motion and massage being freely practised. The advantages of this operation over the use of Malgaigne's hooks or Mayo Robson's pins or other

operative measures seem so considerable that these methods will not be described here.

Operative treatment of old fractures.—If the inconvenience is sufficient to warrant the performance of an operation, the fragments must be wired by the open method advocated by Lister. They are freely exposed by a vertical or transverse incision, freed from their fibrous adhesions, and freshened by removal of a thin piece of the fractured surface, the saw cuts being so planned that accurate apposition can be obtained. Each fragment is now drilled in one or two places, as may seem advisable. The drill enters the anterior surface of the fragment about half an inch from its cut margin, and passes obliquely through the bone, emerging just above the cartilage-covered surface, so that the wire does not enter the joint. The joint is cleaned, the wires are introduced and twisted, and the ends hammered down. If drainage be considered necessary, a small opening is made on the outer side. The wound is sutured and an antiseptic dressing applied. The limb is kept at rest on a back splint for six or eight weeks, but gentle passive motion or massage should be practised in about two or three weeks. The patient may be allowed up on crutches at the end of a month, and must wear a good leather knee-cap for six months more.

FRACTURES OF THE BONES OF THE LEG

Fractures of the shaft of the tibia and fibula.—The shaft of one or both bones may be broken by direct or indirect violence, *e.g.* falls upon the feet. Fracture by indirect violence occurs at the weakest spot, *i.e.* the lower third of the tibia and upper third of the fibula. By direct violence both bones are usually broken at the same level, and the fractures may be compound or comminuted with considerable bruising of the soft structures; by indirect violence the fibula is usually broken about two inches higher up than the tibia; comminution is rare, and bruising at the seat of injury but little marked. The obliquity of the line of fracture is greater in cases of indirect than of direct violence.

If only one bone is broken the degree of displacement may be very slight, and over-riding is prevented by the intact bone acting as a splint. When both bones are broken the line of fracture in the tibia is oblique from above downwards, inwards, and forwards, the lower fragment being drawn upwards behind the upper by the calf muscles (Fig. 74, p. 188); the sharp edge of the upper fragment

projects beneath, or may lacerate the skin. As the patient lies in bed, the lower fragment will be rotated outwards by the weight of the foot.

The diagnosis of fracture is usually easy; it is rendered more difficult if only one bone is broken, and there is no displacement. In the case of the fibula the difficulty is increased owing to the bone being concealed, at its upper part, by the peronei and extensor muscles. In cases of doubt the bones should be grasped and squeezed together, when the patient will complain of a pricking pain at the seat of fracture, and crepitus may be detected; in addition, if the bone be not broken the surgeon will feel the natural "spring" of the fibula.

FIG. 74.—Fracture of the bones of the leg (Gray, after Hind).

Treatment.—Great care must be taken in handling the leg, or the sharp upper fragment may be pushed through the skin and the fracture be rendered compound. If, as is often the case, there is much bruising and swelling, the limb should be placed between Cline's splints or on an Arnold's splint, and swung in a Salter's cradle, so as to relax the muscles, and the ice-bag must be employed for a few days until all danger of gangrene has passed. M'Intyre's splint is specially useful if there be much displacement and difficulty in reduction or in maintenance of the fragments in apposition owing to contraction of the calf muscles. If muscular spasm is very great, it may be partly overcome by flexion of the knee, but if this fails, chloroform must be given. If there is but little swelling or displacement, the limb may be at once fixed in plaster or with Croft's plaster splints.

Croft's splints consist of four pieces of house flannel reaching from the knee to the heads of the metatarsal bones; two are fitted to each side of the limb and the outer ones are soaked in wet plaster,

squeezed dry, and applied to the inner piece of flannel, the outer surface of which is also coated with wet plaster. The splints are retained in position by a few turns of ordinary or plaster bandage, and if necessary, the casing, when it has set, may be split up along the front, trimmed, and reapplied.

Cline's or Arnold's splints are also very useful, especially if there be much bruising.

The surgeon should take care that the foot is nearly at right angles with the leg and the ball of the great toe in a line with the inner border of the patella. Complete rest should be given for six weeks, but if the limb is fixed in plaster the patient may be allowed up on crutches at the end of the third; if only the fibula is broken, he need not be confined to bed for more than a day or two.

Fracture or separation of the epiphysis of the upper end of the tibia only occurs from direct violence. In the case of fracture, the upper fragment may be much comminuted and the joint involved; one tuberosity may be completely separated, causing a broadening of the knee. These injuries are best treated by M'Intyre's splint, combined with aspiration and cold applications, if there is much extravasation or effusion into the joint.

Fractures at the ankle joint—Pott's fracture.—Pott's fracture is a very common accident as the result of sudden twists of the foot outwards, as, for instance, in slipping off the kerb. The precise nature of a fracture at the ankle varies with the method and violence of its production. The typical Pott is a fracture of the fibula from about two to four inches above the malleolus, accompanied by fracture of the internal malleolus, or rupture of the internal lateral ligament

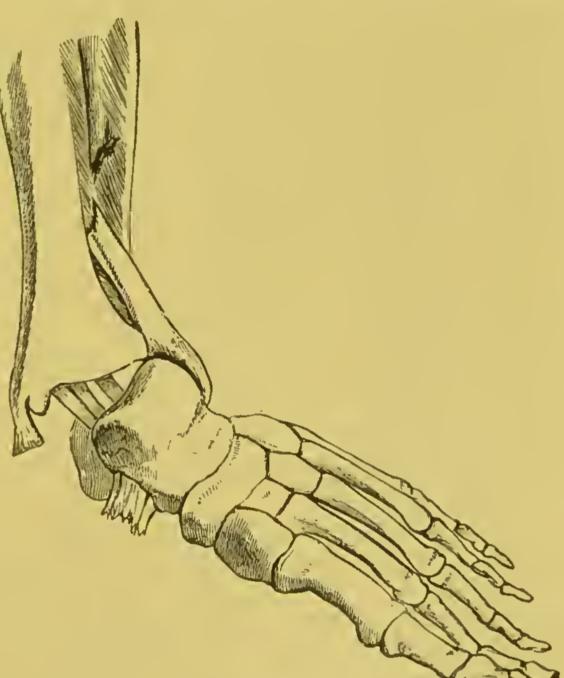


FIG. 75.—Pott's fracture (Gray, after Hind).

with partial dislocation of the foot outwards (Fig. 75, p. 189). Sometimes both malleoli are broken, and the foot is partially dislocated backwards; or both bones may be broken at the lower end, the lower fragment of the tibia being comminuted and the joint opened.

Signs.—The displacement varies with the damage done. In Pott's fracture the foot is forcibly twisted outwards, the inner border resting on the ground; the heel is drawn upwards and backwards by the calf muscles, and the toes point downwards. Crepitus is usually distinct, especially if the two bones are pressed together at the upper part. The swelling and bruising may be considerable, especially if the ligaments are torn and the joint is involved.

Treatment.—If there is not much swelling, the plaster casing may be applied at once, and the patient allowed up in a few days. If this is not advisable, Cline's or Arnold's splint should be used, and the limb suspended by a Salter's cradle. If eversion of the foot is very marked, Dupuytren's splint (resembling a short Liston) should be applied to the inner side of the leg, reaching from just below the knee to about four inches below the heel (Fig. 76). Roughton's splint is useful in cases of marked outward and backward displacement. The parts should be kept at rest for six weeks, but gentle massage and passive motion should be begun as early as possible.

FIG. 76.—Dupuytren's splint for cases of Pott's fracture in which there is much eversion of the foot (Berkeley Hill).

Separation of the lower epiphysis of the tibia, which joins the shaft at the twentieth year, may be occasioned by sudden twists of the foot. The line of fracture usually passes through the diaphysis at one part. The fibular epiphysis is very rarely damaged. If arrest of growth of the tibia should result the fibula may become curved, or else, as it increases in length, the malleolus pressing against the foot may push it inwards, so that talipes varus is produced. Such deformity may be corrected by removing a piece of the lower third of the fibula.

Separation of the epiphysis is best treated by the plaster or starch bandage.

FRACTURES OF THE FOOT

These injuries are usually due to direct violence of a crushing nature, such as the passage of a cart wheel, and hence they are often compound and accompanied by laceration and contusion of the soft structures.

Fractures of the tarsal bones—**The astragalus** is very rarely broken, unless the foot be dislocated. The neck is the usual seat of the accident. In simple, uncomplicated cases the diagnosis is difficult. There is no displacement, and crepitus cannot always be obtained, but the patient is unable to stand, and movement at the ankle causes great pain.

The os calcis is broken by falls upon the heel, the bone giving way in front of or behind the interosseous ligament ; in the latter case the fragment is drawn upwards by the tendo Achillis. The epiphysis, joining at the fifteenth year, may be separated.

The other tarsal bones are only broken by crushes.

Treatment.—Plaster of Paris is the most appropriate method of treatment. If there is much swelling the ice-bag should be applied for a few days, the limb being placed in Cline's splints. Compound fractures may require amputation, or in the case of the astragalus, the bone may be excised. If the posterior fragment of the os calcis cannot be kept in position the tendo Achillis may be divided, or the fragment may be pegged from behind.

Fracture of the metatarsal bones and phalanges should be treated with plaster of Paris.

Dislocations

DISLOCATIONS OF THE FEMUR

Dislocation at the hip is, in spite of its being at the end of a long and powerful lever, a rare accident on account of the completeness of the joint and the strength of the ligaments. Much of our knowledge on this subject is due to the work of Bigelow, who has shown that the Y-ligament is the chief structure determining the position of the limb, and offering the main obstacle to reduction. This ligament is attached above to the anterior inferior iliac spine ; below it spreads out in a fan-shaped manner, and is attached to the anterior inter-trochanteric line ; it consists of a strong inner and outer fasciculus, connected by a thinner portion, and united at the upper attachment. The acetabulum is shallow and incomplete

downwards and inwards; it is against this portion that the head of the femur rests when flexed and abducted. In this position also the round ligament is lax, and hence very likely to be lacerated by any sudden jerk.

The capsule of the joint, strengthened in front by the Y-ligament, is weakest below and behind, opposite the acetabular notch; in the majority of cases it is here that the head of the bone leaves its socket, its ultimate position being due to muscular action and the continuance and direction of the force which brings about the displacement.

Varieties and causes.—Bigelow classifies dislocations of the hip into "regular" and "irregular"; in the former, the Y-ligament is intact, or only partially torn, and the signs are fairly constant; while in the latter the ligament is completely torn, the soft structures are much damaged, and, as the name implies, the head of the bone may assume various positions, and the signs be inconstant. The regular dislocations will now be described. The head of the bone may pass—

(1) Backward on to the dorsum ilii.
  (*a*) Above the tendon of the obturator internus, or
  (*b*) Below it (*sciatic dislocation*).
(2) Forwards and downwards (*thyroid*).
(3) Forwards and upwards (*pubic*).

Subvarieties of these dislocations will be presently referred to.

The dorsal dislocations are caused by violence applied to the sacral region, or to the limb, when the thigh is flexed and adducted; or sometimes when it is abducted and rotated in. In the latter case the dorsal position of the head is secondary, as it leaves the acetabulum below.

If flexion is marked, the dislocation is more likely to be below than above the tendon. Some surgeons consider that all, or nearly all, dorsal dislocations are primarily below the tendon, and that the position above is secondary only.

The thyroid and pubic dislocations are produced by violence when the limb is widely abducted, the latter resulting if the femur is at the same time extended or rotated outwards.

The dorsal dislocations above and below the tendon of the obturator internus.

Anatomy.—The Y-ligament is intact, the outer band being very tense and holding the trochanter forwards, thus maintaining the inversion of the limb. If the outer band of this ligament be torn, the femur may be everted (*everted dorsal dislocation*).

The lower and posterior part of the capsule is extensively torn, and the ligamentum teres partially or wholly ruptured. The rent in the capsule is usually extensive, but may be comparatively small, grasping the neck of the bone which has torn it. The small external rotators are stretched or torn, and the glutei are pushed aside and partially lacerated. In the dislocation above the tendon the head of the bone rests upon the gluteus minimus; in that below the tendon it lies upon the upper margin of the sciatic

FIG. 77.—Dorsal dislocation below the tendon of the obturator internus, which prevents the head of the femur from slipping upwards (Bigelow).

notch (Fig. 77), and the sciatic nerve may be compressed or stretched over the head. When the head of the femur passes out below the tendon, it slips upwards as the limb is extended until arrested by the tension of the tendon and capsule against its neck. The ilio-psoas and adductor muscles are stretched and tense, and the margin of the acetabulum may be chipped.

Signs.—When the head is displaced above the tendon of the obturator internus, it can be felt in its new situation moving with the movements of the thigh. The normal outline of the buttock, which becomes broadened and prominent, is lost. The great

trochanter is approximated to the anterior superior iliac spine, and lies above a line drawn from that point to the tuber ischii (Nélaton's line).

The thigh is adducted, internally rotated, and advanced, and its axis crosses obliquely the lower end of the opposite thigh, the toes being inverted and resting on some part of the opposite foot, usually the instep (Fig. 78).

FIG. 78.—The attitude assumed in a case of dorsal dislocation of the right hip (Fergusson).

The degree of shortening varies with the height to which the femoral head ascends on the dorsum, and is usually about one or one and a half inch. Movements of abduction and eversion are lost; slight flexion is possible, but if any attempt is made to straighten the advanced thigh there is compensatory arching forwards of the lumbar spine, and the bend of the column and tilting forwards of the pelvis becomes very evident if the patient assumes the erect posture.

The signs of dislocation below the tendon are practically the same as those above it, but the flexion, adduction, and inversion are more marked, and there is less shortening.

Reduction.—As the Y-ligament offers the chief bar to reduction of all regular dislocations at the hip joint, the movements imparted to the femur must be such as will relax this structure; this object is attained by flexion of the thigh on the abdomen. Certain rotatory and other movements are also employed with the view of making the head of the bone approach and finally enter the socket along the path by which it came out. Reduction by manipulation is now universally employed, the pulleys being practically obsolete in recent cases.

In all forms of dislocation the patient is most conveniently placed upon a hard mattress on the floor, the surgeon having thus full command over the limb. He must be fully anæsthetised. In the dorsal dislocations the surgeon, flexing the knee to a right angle, grasps the leg above the ankle, and just below the knee. The thigh is now flexed on the abdomen to a right angle, and the patient is slightly raised from the mattress so that his body becomes a counter-extending force; if this be insufficient his pelvis may be fixed by an assistant, or the surgeon may exert pressure on the

anterior superior iliac spine with his unbooted foot. The femur is now abducted and rotated out, and thus the head is brought nearer to the acetabulum; finally, the limb is extended and the head slips into its socket. The formula for reduction is "lift up, bend up, bend out, roll out, and extend." If any difficulty is experienced it will most likely be due, not only in the dorsal, but in all regular dislocations, to the smallness of the aperture in the capsule; this may be made larger, without fear of inflicting much additional damage, by circumduction in the direction opposite to that which the head of the bone must subsequently travel. In other cases adduction and inversion may be slightly increased in order to disengage the head of the bone.

Anomalous dorsal dislocations—*Everted dorsal.*—If the outer fasciculus of the Y-ligament is ruptured the limb may be everted, but is not necessarily so; it is at the same time slightly abducted, and hence the position simulates that of fracture of the neck of the femur. This dislocation may be readily converted into the ordinary dorsal form by flexion, adduction, and inward rotation of the limb.

Supra-spinous.—The outer band of the Y-ligament is torn, and the head ascends above the anterior inferior iliac spine, the neck resting against the notch and hooking over the unruptured inner fasciculus of the ligament. The limb is, according to Bigelow, shortened by two or three inches, slightly abducted, and much everted.

Bigelow recommends that the head should be disengaged by circumduction of the extended limb inwards, coupled with eversion to free it from the edge of the pelvis. By this manœuvre the head is placed upon the dorsum and may be reduced in the ordinary way.

Anterior oblique.—This is practically the same as the supraspinous, but with the important difference that the Y-ligament is intact, hence the obliquity. If the ligament yields, the head will ascend and supraspinous dislocation result. In the anterior oblique dislocation the thigh is everted and crosses the opposite one high up, the toes being turned outwards. It may be converted into the ordinary dorsal form by inward circumduction and internal rotation.

Dislocation forwards and downwards—Thyroid.

Anatomy.—The head of the bone usually passes downwards and inwards, rupturing the capsule at its weakest part and resting on the obturator externus and margin of the thyroid notch. Rarely it passes forwards into the perineum (*perineal dislocation*), or more directly downwards on to or slightly behind the tuber ischii.

It sometimes happens that the dislocation below the tendon on to the dorsum ilii is, during attempts at reduction, converted into the thyroid displacement.

The adductor muscles are stretched, and the small external rotators, glutei, and ilio-psoas are more or less lacerated. The obturator nerve may be compressed or torn.

Signs.—The buttock is flattened and the great trochanter, which is carried inwards, is less prominent and felt with difficulty. The limb is lengthened by one or two inches, and as the pelvis is tilted to the injured side the length appears even greater. The thigh is flexed, abducted, and advanced; the toes point downwards and forwards and are slightly everted. In the perineal dislocation, flexion and abduction of the thigh are extreme.

Reduction.—The patient being in the same position and the surgeon holding the limb as in the dorsal dislocation, the thigh is flexed upon the abdomen and then strongly rotated in and adducted so that the head of the bone is directed towards the socket; finally, the limb is extended in the adducted position. Circumduction may be necessary to enlarge the rent in the capsule. If the head of the femur has slipped as far as the perineum, direct traction in the axis of the thigh will convert the dislocation into the ordinary thyroid form, when reduction is effected as above stated.

Sir Astley Cooper's method of reduction by pulleys is as follows:—

The surgeon, standing on the uninjured side of the patient, passes his arm beneath the sound leg, grasps the dislocated limb above the ankle and strongly adducts it, while the pulleys, fixed round the upper part of the thigh, make traction upwards and outwards and so drag the head into the acetabulum.

Dislocation forwards and upwards — Pubic dislocation — *Anatomy.*—The head of the bone usually lies against the point of union of the pubic bone and ilium, but in some cases just beneath the anterior inferior iliac spine (*subspinous form*, Fig. 79). If the inner band of the Y-ligament is torn, the head may slip forwards towards the symphysis. The obturator internus is tense, and assists in producing eversion; the small external rotators are torn, and the head of the femur lies beneath the ilio-psoas and external to the vessels.

Signs.—The buttock is flattened, the trochanter absent from its usual situation, and the head forms a prominence on the pubes. The limb is shortened by one or two inches, flexed, abducted, and

rotated out. The degree of abduction depends upon how far the head is displaced in the direction of the symphysis. Eversion is marked, and is due to the tension of the Y-ligament, obturator internus, and ilio-psoas muscles.

Reduction is accomplished in much the same way as in the thyroid dislocation. The limb should be flexed in the abducted position, rotated inwards, and adducted and finally extended. Should difficulty be experienced, the abduction and eversion may be slightly increased at first in order to disengage the head, or the rent in the capsule may be enlarged by circumduction.

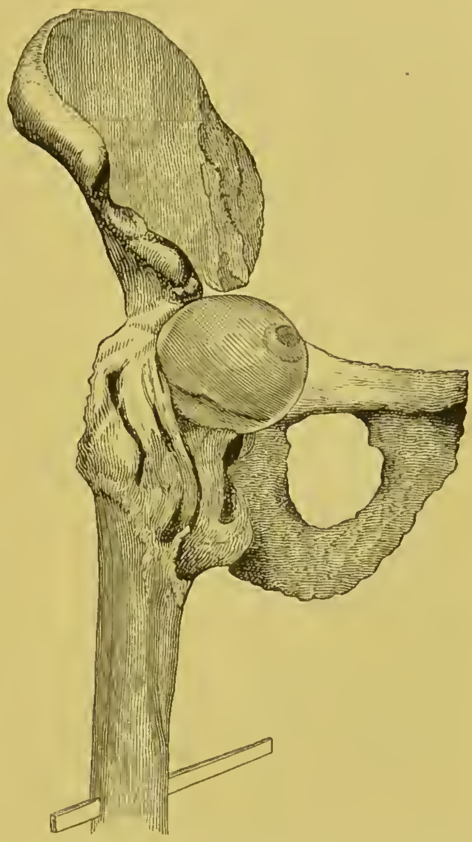


FIG. 79.—Subspinous dislocation of the femur. The neck of the bone is seen lying beneath the Y-ligament, which is tightly stretched across it (Bigelow).

After-treatment of dislocations at the hip.—When reduction has been effected the patient must be kept in bed for about fourteen days, the limb being fixed by a long splint. At the end of this time, passive motion should be employed and the patient may be allowed on crutches, but should not use the limb till the end of a month. As a rule all support may be dispensed with at the end of six weeks.

Unreduced dislocations.—As a rule no attempt should be made to effect reduction after two months, and even at this date failure is common, and forcible attempts at reduction are dangerous. In all cases deep anæsthesia is necessary. The adhesions must be broken down and manipulation employed; failing this, pulleys must be resorted to. It should be remembered that fracture of the neck of the bone is readily occasioned by undue violence.

If the bone is left unreduced, fair mobility and usefulness may result; but should this not be so, the neck of the bone may be divided or the head excised.

CONGENITAL DISLOCATION AT THE HIP[1]

Congenital dislocation of the hip may affect one or both sides and is more common in the female sex. The head of the bone usually lies on the dorsum ilii, but may pass in any direction. It may be absent or misshapen, and the acetabulum shallow or represented by a mass of fibrous tissue. Where the femur impinges against the ilium, a slight excavation represents an imperfect articular cavity. The ilium or pelvis generally may be ill-formed. After the first two years of life these changes become more marked, and hence curative treatment should be adopted early.

If the condition is bilateral and symmetrical, it is often unrecognised until the child begins to walk, when the peculiarity of its gait leads to an examination; but if only one side is affected, the want of symmetry early attracts attention. In bilateral cases the shortness of the lower as compared with the upper limbs is very noticeable. The lower limbs are ill-developed, and the thighs slope inwards from above; the trochanters are prominent and above Nélaton's line (*i.e.* a line from the anterior superior iliac spine to the tuber ischii); the transverse measurement between the trochanters is increased. The movement of abduction is impaired and compensatory lordosis is present. The child has a peculiar waddling gait and walks on the toes; she is easily fatigued. A very characteristic sign is the great freedom with which the bone, as evidenced by the trochanter, moves in a vertical direction.

Treatment should be begun early before the pathological changes are very marked. By continued extension, abduction, rotation out, and lateral pressure on the trochanters, the displaced bone may be gradually drawn into its normal position. The full degree of extension, etc., is gradually obtained, the limb being drawn week by week nearer to its ultimate situation. A variety of apparatus have been devised for the accomplishment of the object in view; whatever form is used, it must be worn for many weeks for some hours during the day, the length of time being increased as cure progresses. Weight extension may be employed at night with advantage. Mikulicz[2] and Lorenz have devised and used with much success a special apparatus for congenital dislocations of the hip.

[1] For the causes of congenital dislocations, see p. 128.

[2] *Archiv für klin. Chirurg.* Bd. xlix. hft. 2; *Centralblatt für Chirurg.* 1895, pp. 153, 761; *Practitioner*, 1896, Jan. p. 89; Tubby and Jones, *Medical Annual*, 1898.

Fair results have been attained by operative treatment, especially by Hoffa[1] and Lorenz.[2]

The operation consists essentially in exposing the displaced head, freeing it from its surroundings, but sparing as far as possible the integrity of the muscles; the acetabulum is deepened with a curette, and the head placed in it, and the limb maintained in a position of abduction and extension. The limb is fixed in plaster of Paris, and kept immobile for at least a month.

The advisability of resorting to operation must be determined on the merits of each case.

DISLOCATION OF THE PATELLA

Causes.—Displacement of the patella is usually due to sudden muscular action, but it may also result from forcible twists of the joint, or from direct blows on one or other side, the bone being driven in the opposite direction. Laxity of the fascial structures from chronic hydrarthrosis, and genu valgum are predisposing causes.

Varieties. — The patella may be dislocated *outwards* or *inwards*, and may subsequently turn on its edge and assume a vertical position (*rotatory displacement*). The lateral dislocation may be complete, but is usually partial, the lateral half of the articular facet being against the opposite condyle. Dislocation upwards is really more properly regarded as a separation of the tubercle of the tibia, or the apex of the patella, which yield to violence more readily than does the strong ligamentum patellæ. Such cases require the same treatment as for fractured patella.

Dislocation outwards is the more usual injury. The inner facet of the patella rests against the outer condyle, and the outer edge is, owing to the inclination of the articular surface of the condyle, tilted forwards. The capsule is usually intact unless the dislocation be complete, in which case the bone lies against the outer condyle and the inner edge is turned forwards. The internal condyle is prominently outlined beneath the skin, and the patellar tendon takes an oblique course. The knee is broadened, slightly flexed, and immovable, and there is considerable pain. Slight synovitis may ensue.

Dislocation inwards is rare, and presents similar signs to those of the outward displacement, reading inner for outer.

[1] *Archiv für klin. Chirurgie*, Bd. li. 1895.

[2] *Sammlung klin. Vorträge*, No. 117, 1895; *Annals of Surgery*, 1895, vol. i. p. 727; *Practitioner*, 1896, Jan. p. 91.

Rotatory dislocation is consecutive to the partial displacement outwards or inwards, more usually the latter. Lateral dislocation having been produced, the sudden contraction of the quadriceps causes the bone to turn on its axis, the edge nearest the middle line locking in the intercondylar notch, and the other turning forwards; in very rare cases the patella has turned completely over the articular surface then looking forwards. The signs of rotatory displacement are sufficiently obvious; the leg is extended and fixed, and the patella makes a marked prominence in the middle line, and increases the anterior posterior diameter of the joint. The surgeon must accurately ascertain which edge has gone backwards, in order to make pressure in the right direction; otherwise he might turn the bone over.

Reduction of dislocations of the patella is usually easy—indeed, the bone may slip back unaided. In the partial lateral dislocations an anæsthetic is rarely necessary. The thigh must be flexed to a right angle, and the leg extended to relax the quadriceps muscle, and if the bone does not then slip into place, it may be made to do so by lateral pressure. Reduction is sometimes facilitated by forced extension and flexion, and in the rotatory displacement these movements, combined with anæsthesia and pressure on the prominent edge of the patella in such a direction as to tilt it towards the side it belongs, will effect reduction in most cases. If reduction of the rotatory dislocation is impossible, a good joint may, nevertheless in time, be gained. The question of cutting down on the bone, and forcibly replacing it with or without division of its substance, must be decided on the merits of the case. Such a proceeding is practically similar to that adopted in some cases of fracture of the bone, but is only justifiable in the case of young and healthy patients, and provided the strictest antiseptic precautions can be observed.

After-treatment consists in complete rest on a back splint, and the application of an ice-bag for ten days or a fortnight. The patient should then be provided with a stout knee-cap, and warned that the accident may recur from slight causes. If synovitis ensues, rest may be necessary for a longer period.

DISLOCATIONS OF THE TIBIA

Causes and Varieties.—Dislocations at the knee joint are rare accidents on account of its shape and the great strength of the ligaments. They are produced by very severe direct violence,

or by twists and wrenches when the foot is fixed. Antero-posterior dislocations are usually complete and often compound, and may be complicated with fracture of one or both condyles of the femur. The lateral displacements are often incomplete, and may be associated with dislocation of the patella to the same side.

Anatomy.—The posterior, crucial, and lateral ligaments are lacerated, the hamstrings stretched or ruptured, and the poplitcal vessels and nerves similarly injured.

Signs—**Dislocation forwards** is the most usual injury. The head of the tibia rests against the anterior articular facet of the femur, and the leg is usually extended, but may be slightly flexed. The condyles project backwards, and form a characteristic prominence in the ham; the vessels and nerves are stretched, and may be torn. There is great pain, the joint is immovable, and the leg shortened.

Dislocation backwards.—The leg is flexed, and the condyles, the patella, and its ligaments form a prominence anteriorly. The head of the tibia rests against the posterior surface of the condyles, or against the popliteal surface of the femur. The joint is fixed, and pain is very severe. There is slight shortening.

Lateral dislocations are usually incomplete, the condyle of the femur resting on the opposite articular surface of the tibia. In the outwards dislocation the internal condyle forms a marked prominence on the inner side of the joint, with a depression below; while on a level with this depression, but on the outer side, is the prominence formed by the head of the tibia, with a depression above it. The inward dislocation presents the same appearances reversed.

There is no shortening of the leg, which is usually extended. The breadth of the joint is increased, and the patellar tendon is directed obliquely towards the side of the dislocation.

Prognosis.—Simple dislocations at the knee, unaccompanied by laceration of the vessels and nerves, lead to little future trouble if reduced at once, and provided rest be long enough maintained. Gangrene sometimes results in consequence of changes in the contused vessels.

Reduction.—Anæsthesia is necessary to overcome the contraction of the powerful muscles. Forced flexion and slight rotatory movement of the tibia, combined with traction at the ankle, usually prove successful; should this fail, greater extension must be employed with counter-extension at the lower end of the femur or perineum. The pulleys must be used if necessary.

After-treatment.—Complete rest on a back splint must be observed for three weeks at least, and an ice-bag should be applied for the first few days, or as long as any swelling or synovitis persists. Gentle passive motion should be begun at the end of a fortnight, and the patient should wear a strong knee-cap for six months or more.

Compound dislocations of the tibia are usually backwards or forwards, and require amputation more often than not. If the wound is very small, and there is but little laceration of the tissues, an attempt may be made to save the joint, with or without excision, according to circumstances.

DISPLACEMENT OF THE SEMI-LUNAR FIBRO-CARTILAGES

This accident is occasioned by sudden twisting or wrenching of the knee when it is semi-flexed. Forced rotation outwards displaces the internal cartilage, which is by far the most common accident; the external cartilage being displaced when the leg is rotated inwards.

The cartilage may be completely torn away, although this is very rare; more usually the anterior end is torn and is displaced towards the middle line or marginally.

Signs.—The signs are similar to those occasioned by the presence of a foreign body.

At the time of the accident the patient experiences severe and sickening pain in the knee, which is semi-flexed and cannot be extended. If the cartilage has slipped inwards towards the middle line there is a slight depression opposite it, but if it has been displaced marginally, *i.e.* outwards, its presence will be marked by an elevation.

Reduction is usually easy. The flexion should be increased and the leg rotated to the side of the displaced cartilage, when it will slip back into place and the leg may be fully extended. Mild synovitis ensues.

In most cases the accident recurs sooner or later, followed each time by effusion into the joint which may, after repeated attacks, be permanent, causing considerable weakness of the joint and favouring a repetition of the accident.

Treatment.—Reduction having been effected in the manner described, complete rest with the use of the ice-bag will be necessary, in view of the consecutive synovitis, for a week or ten days. The patient should in future wear a well-made knee-cap to

prevent, if possible, a recurrence of the accident, which is very liable to take place in spite of all precautions. If the cartilage becomes frequently displaced, causing the patient much inconvenience, it may be safely removed, provided the strictest asepsis be observed. Removal is far preferable to any attempts at fixing the cartilage by sutures or other means—attempts too often resulting in disappointment to patient and surgeon alike.

DISLOCATIONS OF THE FOOT

Dislocation at the ankle is a rare accident, and is almost always accompanied by fracture of one or both bones of the leg. It is caused by sudden twists, wrenches, or extreme movements of flexion or extension of the joint while the foot is fixed, as when caught in a hole.

Varieties.—The foot may be displaced laterally or anteroposteriorly, and the dislocation is usually partial.

Lateral dislocations.—Dislocation outwards is much more common than inwards. The internal lateral ligament, internal malleolus, or lower end of the fibula may one or all be broken, and the inner half of the articular surface of the astragalus comes in contact with the outer half of the lower end of the tibia. The foot is much everted and rests on its inner border, the deformity being practically that of Pott's fracture.

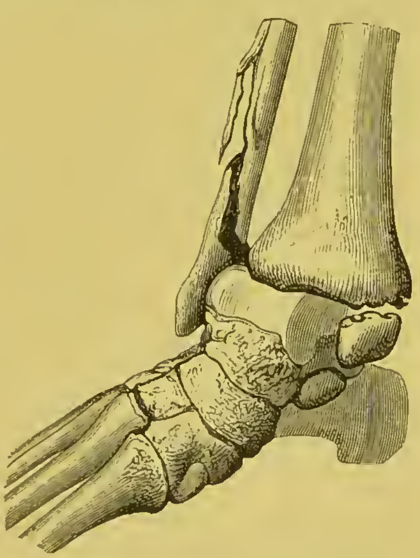


Fig. 80.—Fracture of the lower end of the fibula and of the internal malleolus, with partial dislocation of the foot inwards. Pott's fracture (Follin, after Malgaigne).

In the inward dislocation the external lateral ligament is torn, and an oblique fracture may extend upwards through the articular surface of the tibia, the position of the foot being the reverse of that seen in displacement outwards. Complete lateral dislocations are rare; they are nearly always compound, and accompanied by much laceration of the tissues on the side opposite to the displacement.

Signs.—In dislocation outwards the sole is directed downwards and outwards, the foot is much everted, the internal malleolus very

prominent, and there is great pain with fixity at the joint. Crepitus is present if fracture has occurred. The signs of internal dislocation are similar—*mutatis mutandis.*

Antero-posterior dislocations—Backward displacement is the most common, is usually incomplete, and is accompanied by fracture of the malleoli or rupture of the lateral ligaments.

Signs.—In dislocation backwards the tibia rests upon the scaphoid or cuneiform bones. The heel is drawn up and projects prominently backwards, the foot is shortened as measured from the anterior margin of the lower end of the tibia, and the toes point downwards.

The tendo Achillis and those on the front of the joint are well defined and tense.

In **the forward displacement** the tibia rests upon the os calcis behind its articular facet; the heel is less prominent and the lower end of the tibia cannot be defined anteriorly where the astragalus forms a characteristic prominence. The foot is lengthened and the tips of the malleoli are nearer the sole than normal.

Dislocation upwards occasionally occurs from heavy falls upon the heel. The tibia and fibula are forcibly separated and the astragalus with the foot is driven up between them. The ankle is very much broadened, the skin stretched or torn, and the malleoli are very prominent and approximated to the sole. The astragalus cannot be defined and fixity is complete. Fracture of one or both bones is common.

Reduction may sometimes be easily effected without an anæsthetic, which, however, should always be given if any difficulty is experienced. The thigh is flexed to a right angle with the trunk and the leg upon the thigh, in order to relax the calf muscles. An assistant makes counter-extension at the lower third of the thigh, while the surgeon makes traction upon the dislocated foot accompanied, in the lateral displacements, by forcible abduction or adduction according to the direction. In the antero-posterior dislocations direct pressure should be exerted on the lower end of the tibia, coupled with the extension and counter-extension.

After-treatment.—When reduction has been effected the leg must be placed between sand bags and ice applied to the joint to reduce swelling and reactionary inflammation, after which the limb should be put up in plaster of Paris or some similar immovable apparatus. Complete rest must be maintained for from four to six weeks, but the patient may be allowed up on crutches at the end of a week or ten days, when assiduous massage, douching, friction, and gentle

passive motion should be employed in order to prevent stiffness and fixity about the joint and tendinous structures.

Compound dislocation at the ankle.—Amputation is necessary if there is much laceration of the soft structures or extensive comminution of the bones, or if the patient is aged or in poor health. In more favourable cases an attempt may be made to save the foot. Removal of the astragalus is sometimes a wise proceeding in order to give more perfect relaxation and rest and thereby minimise the risk of secondary destructive inflammation. Each case must be treated on its own merits.

DISLOCATION OF THE ASTRAGALUS

The astragalus may be displaced forwards or backwards from all the bones with which it articulates. These accidents may be partial or complete, and are associated with some rotation of the bone producing a lateral displacement. Most usually the astragalus is directed forwards and outwards. The accident occurs through severe wrenching of the extended foot or in consequence of a fall from a height upon the heel. One or both malleoli, or the neck of the astragalus, may be fractured.

Signs.—In the forward and outward dislocation the signs are sufficiently evident. The astragalus is thrown forwards and forms a marked prominence on the dorsum of the foot, over which the skin is tightly stretched. The foot is displaced laterally and the malleoli approach the sole. The lower end of the tibia is concealed by the astragalus. This accident is frequently compound and accompanied by much laceration of the soft structures.

Reduction may be impossible and usually is so if the bone is displaced backwards. Extension and counter-extension with direct pressure on the dislocated bone should be employed, as in dislocations of the foot, and reduction may be facilitated by division of the tendo Achillis or others which are stretched and tense. If reduction be impossible, and in all cases of compound dislocation, the astragalus should be excised at once; if it be left severe inflammation with suppuration will ensue, necessitating secondary amputation.

SUBASTRAGALOID DISLOCATION

The calcaneum and scaphoid with the rest of the foot may be separated from the astragalus, which still retains its normal relation

to the bones of the leg, by causes similar to those producing dislocations of the foot or astragalus. The accident is nearly always incomplete, and the foot may be displaced forwards or backwards with lateral inclination.

The ligaments are much lacerated, and the malleoli, astragalus, or other bones may be broken. The deformity depends upon the direction of the dislocation, which is most usually backwards. Under such circumstances the head of the astragalus forms a prominence beneath the tense skin, the calcaneum projects backwards, and the foot is shortened, extended, and twisted laterally.

Reduction may be effected in the same manner as in dislocation of the astragalus. If the injury is compound, amputation by Syme's or the subastragaloid method will probably be necessary.

OTHER TARSAL DISLOCATIONS

Dislocation very occasionally occurs at the transverse tarsal articulation from falls from a height, the anterior portion of the foot being displaced on the dorsum; consequently the arch of the instep is increased and the toes point downwards.

The calcaneum and cuneiform bones have occasionally been displaced alone.

DISLOCATION OF THE METATARSAL BONES

The whole row, or individual bones, may be displaced upwards on to the dorsum by falls upon or wrenches of the anterior part of the foot. These accidents are very rare.

DISLOCATIONS OF THE PHALANGES

These injuries closely resemble, but are much rarer than, those of the fingers (see p. 173).

CHAPTER XI

AMPUTATIONS [1]

A LIMB may require removal on account of injury or disease.

When no attempt is made to save an injured limb, the amputation is said to be **primary,** but when conservative surgery has been tried and has failed, **secondary** amputation must be performed. Amputation through a joint is sometimes spoken of as **disarticulation.**

In planning an amputation it must be remembered (1) that it must be performed in such a manner that union will be rapid and unattended by consecutive inflammation or suppuration; (2) that a good sound stump should result; and (3) that as little as possible is sacrificed consistently with these views and the removal of all diseased or damaged structures. It is important to note that the nearer the amputation is performed to the trunk, the greater will be the shock of the operation.

The general principles involved.—In order to obtain a good stump certain general principles must always guide the surgeon in the selection and performance of any amputation.

A good stump must be soundly healed, freely movable, painless, capable of sustaining considerable weight or pressure, more or less regular in outline, plump and rounded, with the scar out of the line of pressure and easily movable on the subjacent tissues.

For these desiderata to be fulfilled, it is essential that the covering made at the time of operation should be ample to cover in the face of the stump when contraction has been allowed for; that the skin should be taken, if possible, from the tougher and denser side of the limb, and especially should that be taken which has been accustomed to pressure. To allow of accurate fitting and the least extent of scar, the flaps should be carefully fashioned, so that they

[1] The figures in this chapter are, unless otherwise indicated, from drawings by Miss Booth.

are mutually adaptable; and in order that the resulting scar may be away from the line of direct pressure, it is often advisable that one flap should be a little longer than the other. That healing may be rapid and sound, and that the scar may not be broad, it is necessary that the operation be conducted on strict aseptic principles, that the amputation be not carried through diseased tissue, that the flaps and face of the stump be not damaged by the knife or saw, or by any manipulation necessary, that drainage be provided for, that tension be avoided, and that the dressings be disturbed as little as possible.

Various methods employed.—Whatever method of amputating be adopted in any given case, the amount of covering must never be less than one and a half diameter of the limb at the point of section of the bone, and in very muscular parts, especially the thigh where retraction will be considerable, two diameters will not be found to be too much. If at the completion of the operation the covering be found to fit *accurately* the amputation is a bad one, for the subsequent and inevitable retraction will tend to separate the line of suture and may possibly result in protrusion of the bone, necessitating re-amputation. It is always better to cut the covering too long rather than too short.

The covering, moreover, must not contain too much muscle, or a large heavy mass is left which is not only unnecessary, but may, owing to the contraction of the muscle, retard union in consequence of want of rest; moreover, a large quantity of muscle favours retraction. It is, therefore, impossible to give any one method for amputation at any given point which will be equally suitable for all individuals, the method of forming the covering depending in large measure upon the natural muscular development; thus in thin non-muscular persons all or nearly all the muscle may be utilised, but in stout muscular individuals skin and deep fascia should form the principal bulk of the covering, a little muscle being left at the base round the bone. Moreover, the state of the tissues may render necessary considerable modification of the flaps which would be usually employed.

Circular amputation (Fig. 89, p. 218).—This method consists in dividing by a circular sweep of the knife the skin and deep fascia about a diameter, or a little less below the point at which it is intended to saw the bone. The skin and deep fascia are then turned backwards for two-thirds of the distance, at which point the muscles are divided by a circular sweep and retracted from the bone by a few touches of the knife up to the point at which it is to

be sawn. The scar lies over the end of the stump, but if the wound heals rapidly this is of little importance. The circular method has the advantage of making a comparatively small wound, with a covering which is well supplied with blood. It gives excellent results in the arm, provided this be not very large and muscular, it may also be used in the lower third of the thigh, especially when a small wound is a desideratum.

Modified circular (Fig. 103, p. 226).—Instead of dividing the skin and fascia by a circular sweep, two short flaps are cut and reflected, then the skin and fascia is further circularly dissected up for a distance equal to the length of the flaps; the muscles are then circularly divided and the operation is finished as in the ordinary circular amputation. This method may be used in the same cases as the circular; it is easier of performance, owing to the formation of the small flaps which enables the skin and fascia to be reflected with less difficulty, and it is preferable to the simple circular amputation if the limb is very muscular.

Oval and racquet amputation (Figs. 90, p. 219; 84, p. 215).—A longitudinal incision is carried down the limb for some distance in a line away from the vessels; at the end of this cut the knife is carried with slight obliquity or circularly round the limb. The flaps are then reflected and the bone is sawn. The oval method is especially applicable to disarticulation at the hip or shoulder and in amputation of the fingers and toes.

Flap amputation.—Amputation by flaps is the method which is most usually employed. The flaps may be cut from within outwards (*transfixion*), or by dissection from without inwards, or one may be cut by the former, and the other by the latter method. Transfixion is now but little employed, since in view of anæsthesia there is no need for hurry, and by cutting from without in the flaps can be better fashioned and the surgeon can take as much or as little muscle as he may require. Flaps may be taken from any part of the limb, thus they may be antero-posterior (Fig. 101, p. 225), or lateral (Fig. 98, p. 225); they may be equal in size, or may be of different lengths, and in some cases only one flap is used, the opposite portion of the limb being divided by a semicircular incision (Fig. 100, p. 225).

In planning flaps it is advisable, if circumstances permit, to form the largest flap, *i.e.* the one which will cover the greater part of the stump from the toughest portion of skin, because it will be the better able to withstand pressure.

Flaps are usually square with rounded angles so that they

become rather oval; but they may be cut of almost any shape to suit the requirements of the case. Teale's method of amputating by a long square flap equal in all its measurements to one-half the circumference of the limb at the point of amputation, and a second flap one-third the size of this, is but little employed since so much integument is necessary (Fig. 99, p. 225).

The performance of an amputation—Preparation of the patient.—The limb must be thoroughly cleaned (see p. 5), and the hair should be shaved from the area of operation and as far as the dressing will cover. If the operation is undertaken for disease and septic sinuses are present, these should, for some days previously, be carefully attended to, being cleaned and dressed antiseptically, so that danger of infecting the stump from them may be averted. In cases of primary amputation for injury great care should be taken to thoroughly disinfect the parts, especially if the tissues have been begrimed with mud (p. 12).

At the time of operation the limb should be enveloped in carbolised towels, so that the injured or diseased part is carefully covered up and isolated.

Every precaution must be taken against shock; the patient must be warmly clad and hot bottles should be in readiness. When shock is expected, an enema of beef-tea and brandy should be given half an hour before the operation, and during it hot brandy and water may be injected into the rectum (see p. 21).

The arrest of hæmorrhage.—The limb should be simply elevated for a few minutes, or the elastic bandage may be firmly applied from below upwards, so as to partially empty it of blood, and hence limit the amount lost. The elastic tourniquet is then placed on the limb well above the seat of amputation, and the skin is protected by wrapping round it a piece of wet lint. In amputating at the hip or shoulder, great care must be taken to so adjust the band that when the limb is removed and the flaps fall together it may not slip. In some cases the main artery is best controlled by direct digital pressure by a skilled assistant. This method is especially valuable in amputation at the shoulder joint, the pressure being applied to the third part of the subclavian artery.

The apparatus necessary for the intra-venous injection of saline solution should always be at hand in cases in which profuse bleeding may occur, although such is very rare if proper precautions be taken.

Fashioning the flaps.—The surgeon, standing in that position

which gives him the greatest freedom of action,[1] marks the base of the flaps with his thumb and forefinger, and, entering the knife on the side of the limb farthest from him, cuts them with a bold sweeping movement. The blade of the knife should be held at right angles to the skin, so that the edge of the flaps may be clean cut and not bevelled. The flaps must be made full and broad by not carrying the knife across the limb too soon, otherwise tongue-shaped flaps, narrower at the free end than at the base, will be formed; they should be practically square, with rounded angles. In raising a flap (which is facilitated by the assistant moving the limb in the required direction), the surgeon holds it and makes it tense with one hand, and then rapidly dissects it up by a few light touches of the knife. The *back* of the knife must always be turned towards the flap, so that it be not "scored" as it is being reflected.

The amount of muscle taken in a flap must depend upon the nature of the amputation and the natural fleshiness of the limb. When both flaps have been dissected up, they are turned backwards and protected from injury during the circular division of the remaining soft structure and sawing the bone. The vessels should be cut square.

Sawing the bone.—When the bone is being sawn, the assistant who has charge of the limb must hold it quite steady, for if he bends it away from the saw he may, when the bone is nearly divided, break it and leave a splintered stump, or bending it in the other direction he may "lock" the saw.

The section of the bone is made by long, steady, sweeping cuts from heel to point of the saw, and as it proceeds the handle of the instrument is gradually raised, so that the sawing is finished with the instrument held vertically. When two bones are to be sawn, the more movable should be finished before the more fixed one. When the limb is removed, any spiculæ or rough portions of bone on the sawn stump must be removed with bone forceps, and natural sharp edges (*e.g.* the crest of the tibia) must be rounded off.

Completion of the operation.—The chief vessels are at once sought for and secured, the tourniquet is then gradually loosened and the smaller ones are caught up as soon as their situation is detected by the escape of blood. A skilled assistant should be in readiness to compress the main artery if necessary.

[1] As but few surgeons are ambidexterous, the usual rule is to stand on the right side of the limb to be removed, so that the operator marks his flaps with the finger and thumb of the left hand and enters the knife at the side of the limb farthest from him.

The nerves should be drawn out and cut short, so that they may not be implicated in the scar. Tendons should also be treated in the same way. If the operation has been carried out near a diseased or injured area, the flaps should be carefully examined to ascertain that no diseased or hopelessly damaged tissue has been retained; if such is found to be the case, the tissue in question must be cut away with scissors, or treated by sharp-spooning. If it is found that the flaps are too short to afford ample covering for the stump, the soft parts must be further retracted and the bone sawn through at a higher level. The stump is finally cleansed with hot sterilised water or weak carbolic (1 : 80); if this is used at a temperature of 120° F. it arrests oozing, and tends to stimulate the patient. A flat, hot sponge is now placed over the surface of the stump, while the deep sutures of silkworm gut are introduced, and should remain in position until the greater part of the wound is closed. The superficial sutures should be of horse-hair. A small drainage tube should be put in at either end of the wound, as there will certainly be considerable oozing. They may usually be removed about the third day.

A dry antiseptic dressing is applied, care being taken that, as far as possible, all parts of the stump are brought in contact, so that union by first intention may occur. When the dressing has been bandaged on, it is an excellent plan to apply over all a netted cap, which keeps the dressing firmly applied.

The indications given at p. 11 must determine the necessity for after-dressing; but if all goes well, this need not be done for a week or ten days. It is not necessary to dress the stump merely to remove the drainage tube.

The stump should be kept at perfect rest on a small pillow, being in such a position that the muscles are relaxed, and that the soft parts do not drag away from the face of the stump. If necessary, the stump may be bandaged on to a broad splint; this to a certain extent limits muscular contraction, and hence not only minimises pain but tends to prevent retraction.

THE ANATOMY AND PATHOLOGY OF STUMPS

The characters of a good stump have already been detailed on p. 207.

In the course of time the following changes will occur:—The sawn end of the bone becomes smoothly rounded off; the medullary canal is blocked by new bone, and the whole bone is somewhat

atrophied; the museles which are not used in the movement of the stump undergo fatty degeneration and atrophy, the others eontract new adhesions as points of attaehment, and although their bulk is somewhat diminished retain their normal eharacters. In consequence of museular wasting, the stump to some extent atrophies.

The blood-vessels are obliterated from the point of ligature up to the next branch, and the main vessels are diminished in size proportionately to the less demand for blood. The nerve ends are atrophied, but may develop bulbs (Fig. 81), which may eventually disappear, or require removal. A bursa sometimes forms over the sawn end of the bone.

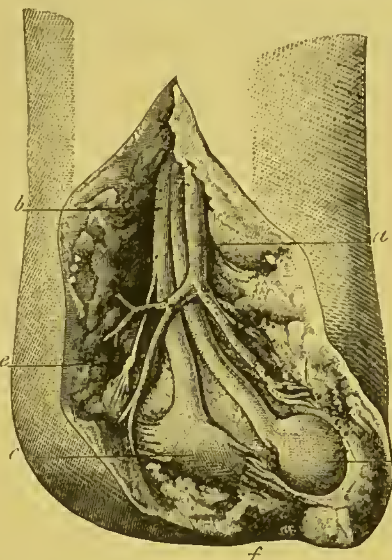


FIG. 81.—A stump after amputation at the ankle joint. The internal and external nerves are implicated in the scar and are bulbous. *a*, posterior tibial artery; *b*, posterior tibial nerve; *c*, bulb on the external plantar nerve, and *d*, on the internal plantar; *e*, small bulb on a branch of the external plantar; *f*, cicatrix (Follin).

Conical stump.—Owing to the partial atrophy of the tissues, most stumps tend to become more or less conieal; but if the covering has been sufficient and has not eontained too much muscle, this atrophy does not cause any ineonvenience. True eonical stump is most often met with in the arm or thigh, and is due to insufficient covering having been provided, together with the subsequent muscular contraetion and atrophy of the soft structures.

In children, conieal stump may oecur in the arm or leg owing to continued growth at the epiphysary line, even after a well-performed operation.

In bad cases the bone first becomes adherent to the eicatrix, and may eventually projeet through it. Re-amputation is the only resource.

Painful stump.—Pain in a stump (sometimes associated with severe museular spasm) may be due to implieation of the nerves in the cieatrix, or to the formation of bulbs and the presenee of adhesions. If the nerves have been properly shortened at the time of operation, these aeeidents do not occur. The pain may be very severe, and the patient ean often localise it to the offending nerves, whieh should be cut down upon and shortened. It is a good plan

to mark out their situation, under the patient's directions, before commencing the operation.

Ulceration of the scar is very likely to occur if it be thin and adherent to the bone, so that it is unfit to bear pressure. In bad cases the best plan is to remove the ulcerated portion and cut off an inch or two of the bone.

Epithelioma of the scar may result from chronic irritation and ulceration.

Necrosis of the bone.—A small ring of bone may undergo necrosis if the periosteum has been stripped up from it during the time of sawing, and especially if suppuration of the wound and osteomyelitis followed the amputation. An abscess forms beneath the scar, and when this has been opened the necrosed bone can be felt at the bottom (see Diseases of Bone, vol. iii.).

Osteomyelitis may occur if the wound becomes the seat of a septic or infective process (see *loc. cit.*).

Arterio-venous aneurism has been met with, but is of great rarity.

Special Amputations

The amputations about to be described as applicable to the various parts are by no means the only ones which can be performed, nor are they always the most suitable in any given case. They have been selected as being the operations which would be performed by most surgeons under ordinary circumstances. The reader must consult a work on Operative Surgery for an account of the numerous modifications and varieties of amputations which are practised.

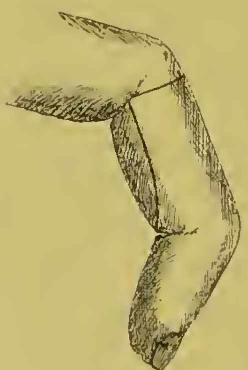


Fig. 82.—Amputation at the inter-phalangeal joint.

Amputations in the Upper Extremity

Amputation at the Inter-phalangeal Articulations

The joint is flexed to a right angle, and being held in this position by the surgeon, is opened by a narrow-bladed knife which is made to cut from heel to point from the end of one lateral crease to the other. The blade of the knife must be held at right angles to the creases so that the joint is opened below the knuckle. The lateral ligaments are divided, and the base of the phalanx is freed so that the knife can be passed to the

palmar surface. The phalanx to be removed is then extended and a good broad square flap is cut from within outwards, *i.e.* practically by transfixion.

AMPUTATION AT THE METACARPO-PHALANGEAL ARTICULATION

The other fingers are held well away from that which is to be removed. The surgeon holding this in one hand enters the knife in the middle line on the dorsal surface just behind the head of the metacarpal bone and makes an incision straight down to the level of the web and thence round the palmar aspect of the finger to complete the racquet. In the case of the index and little fingers the incision should be laterally placed so that the scar is not so visible. As the soft structures are dissected back, care must be taken not to lose sight of the point of the knife, or the tissues which are to be saved may be damaged. The finger is forcibly twisted first to one side then to the other, while the lateral ligaments are divided and the operation is completed.

FIG. 83. — Amputation of the middle finger with part of its metacarpal bone; and of the ring finger at the metacarpo-phalangeal joint.

If the appearance of the hand rather than its usefulness is to be considered, the head of the metacarpal bone should be removed so that the gap left is not so noticeable. This is easily done by bone-forceps if the incision is commenced a little farther back (Fig. 83); the bone should be cut in an oblique direction forwards and towards the palm.

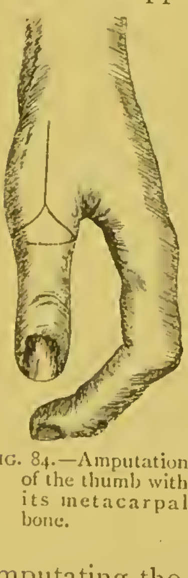


FIG. 84.—Amputation of the thumb with its metacarpal bone.

AMPUTATION OF A FINGER WITH ITS METACARPAL BONE

The incision just described must begin at the base of the metacarpal bone, and the bone isolated by careful dissection so that no damage may be inflicted on the dorsal or deep palmar arches. In amputating the thumb or index finger it must be remembered that

the radial artery passes between the bases of the metacarpal bones and great care must be taken not to damage it.

CONSERVATIVE SURGERY OF THE HAND

In cases of injury every endeavour must be made to preserve as much of the hand as possible—even one digit will prove of great use. The thumb is especially valuable owing to its giving prehensile power to the hand, and it should never be sacrificed unless it is hopelessly smashed; even a small portion of it is useful. The general rule is merely to trim up such parts as are not irretrievably damaged, forming a covering from any skin which will live, and to patch up the damage as well as possible. Under no circumstances must the hand be sacrificed if there is the least hope of an attempt to save it being successful.

AMPUTATION AT THE WRIST

Supinate the forearm, extend the wrist and place the finger and thumb of one hand on the styloid process of the radius and ulna respectively which mark the base of the flaps. A well-rounded palmar flap is now cut extending nearly as low as the line of the superficial arch; this flap is dissected up and must include everything to the depth of the tendons, which are left behind. The forearm is now pronated and an incision is made across the back of the wrist. The wrist is now fully flexed, the joint opened, and the hand removed by division of the lateral ligaments, the tendons, and remaining soft structures.

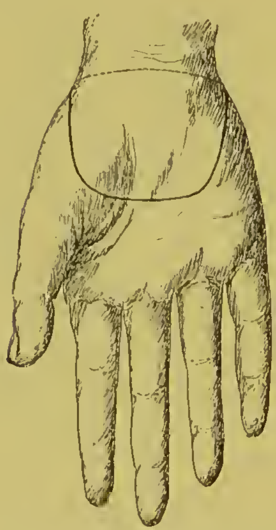


FIG. 85.—Amputation at the wrist by a long palmar flap.

FIG. 86.—Amputation at the wrist joint by Dubreuil's method; and of the little finger with its metacarpal bone.

The operation may also be performed by a long dorsal flap

or by one large flap taken from one side of the hand (Dubreuil's method, Fig. 86). The long palmar flap is well nourished, and hence should always be used when possible.

AMPUTATION THROUGH THE FOREARM

Pronate the limb and place the finger and thumb on the radius and ulna at the point at which the bones are to be sawn. A well-rounded flap about one diameter in length is marked out on the dorsal aspect and a similar but rather shorter one on the anterior surface. The flaps are dissected up; at first skin and deep fascia only are taken, but at the base of the flaps a little muscle should be included. Holding the flaps well back the remaining soft structures are circularly divided, and the knife is thrust through the interosseous membrane so that the bones may be freed in this situation. The forearm is now supinated and the saw is made to cut a slight groove in the ulna (the more fixed bone), and then comes on to the radius, both bones are now sawn together, but the radius should be finished first.

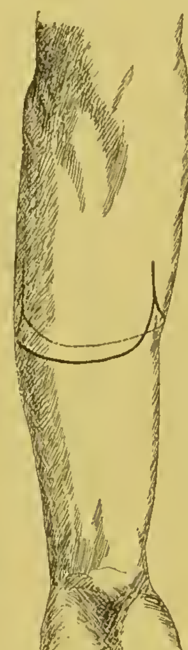


Fig. 87.—Amputation through the forearm by antero-posterior flaps.

In the upper third of the arm the anterior flap may be cut by transfixion, but lower down there are too many tendons to make this a desirable proceeding. For the same reason Teale's amputation is not a good one.

AMPUTATION AT THE ELBOW JOINT

The forearm is fully supinated and a long anterior flap is cut from without in or by transfixion. The base of the flap should be in a line drawn across the joint just below the condyles of the humerus; when the flap is dissected up skin and deep fascia only should be taken at the beginning, but finally all the muscle may be included at its base. A dorsal flap about half the length of the anterior is then marked out and dissected up with the deep fascia. The remaining soft structures are divided and the bones are disarticulated from the outer side.

Lateral flaps may also be employed.

AMPUTATION THROUGH THE ARM

The circular or modified circular methods give excellent results, but the limb may also be removed by antero-posterior or lateral flaps cut from without in or by transfixion.

The circular method is thus performed. The surgeon draws

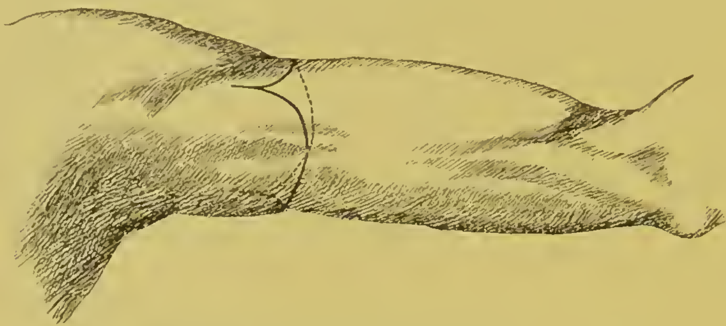


FIG. 88.—Amputation through the arm by lateral flaps.

the skin up as much as he can, and then by a circular sweep divides it and the deep fascia and turns the flap up like the sleeve of a coat for about half a diameter. At this point the muscles

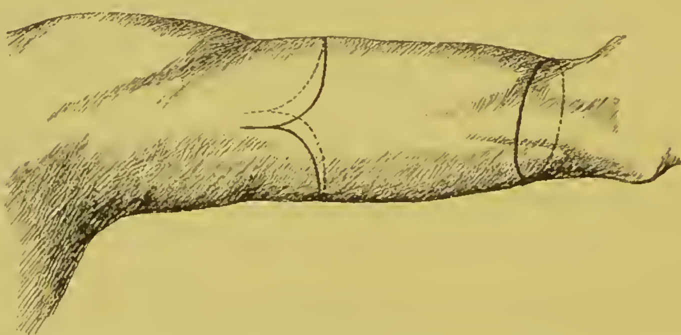


FIG. 89.—Amputation through the upper part of the arm by antero-posterior flaps; through the lower part by the circular method.

are divided by a circular sweep of the knife and are retracted for about half a diameter; the retraction of the muscle is much facilitated if the arm is raised and the muscles are well drawn up by the surgeon.

The bone is sawn and special care must be taken that the musculo-spiral nerve is cut short.

In very muscular arms the modified circular amputation should be performed in place of the pure circular (see p. 209).

AMPUTATION AT THE SHOULDER JOINT

The vessels may be controlled (1) by direct compression of the subclavian artery; (2) by an elastic tourniquet placed round the axillary folds and kept in position by a strip of bandage placed under it in front and behind and held by an assistant so that it may not slip off when the arm is removed and the flaps collapse; or (3) by preliminary ligature of the axillary artery. In most cases the first of these plans will be found quite satisfactory, provided the surgeon has a good assistant.

The oval method is the best, since it keeps the wound away from the axilla and enables the surgeon to examine the joint (if there is any doubt as to its condition) before proceeding with amputation.

The shoulder must be well raised, and the patient drawn to the edge of the table; the arm is held away from the trunk and rotated outwards by a skilled assistant, who manipulates it during the successive stages of the operation. The incision is begun just external to the tip of the acromion process, and is carried straight down the outer side of the arm to the level of the fold of the axilla (Fig. 90).

FIG. 90.—Oval amputation at the shoulder joint.

The oval is completed by making a circular or slightly oblique cut round the arm at this level, dividing skin only on the inner side (so that the vessels may be left till the last), but cutting down to the bone on the outer. The arm is now rotated in, and the outer part of the flap is dissected up, the muscles attached to the greater tuberosity are divided, and the exposed portion of the capsule is cut through; after this is accomplished the arm is rotated outwards, and the subscapularis tendon and inner part of the capsule are cut through. The assistant can now readily force the head of the humerus out of the socket, and the surgeon, passing his knife behind it, divides the remainder of the capsule, and, keeping the knife well against the bone, cuts downwards, and completes the operation by cutting through the undivided vessels and muscles on the inner side. As the last stage is performed the knife is followed by the fingers of a competent assistant, who secures the artery by compression before the final cut is made.

The flap amputation is best performed by cutting, from without inwards, a large external flap which includes the deltoid muscle, and after the head of the bone has been disarticulated, and the vessels secured by digital compression by an assistant, a small axillary flap is cut from within outwards. The surgeon usually holds the limb while the assistant retracts the flap. Lateral flaps may also be used; they should be made from a point just outside and below the coracoid process to the centre of the axilla, and should be about four inches in length; as the anterior flap is being raised the vessels are easily exposed, and can be secured before they are divided. This method has the disadvantage of carrying the incision into the axilla.

AMPUTATION OF THE UPPER LIMB WITH THE SCAPULA AND PART OF THE CLAVICLE ("FORE-QUARTER")

The patient is placed in the same position as for amputation at the shoulder joint. No precautions are taken against hæmorrhage, as the artery is secured in the first stage of the operation.

An incision is made along the outer two-thirds of the clavicle, and the bone is at once divided where it is exposed at the inner end, and the subclavian or axillary vessels are secured and divided. The incision is now prolonged over the shoulder, and backwards along the posterior fold of the axilla as far as the inferior angle of the scapula. The flap thus marked out is dissected up; the muscles are detached from the upper and vertebral borders of the scapula and the supra-scapular and posterior scapular vessels are secured.

FIG. 91.—Amputation of the arm with the scapula and part of the clavicle.

From the incision over the shoulder a second cut is carried along the anterior and inner side of the arm to join the first, where it is carried backwards along the axillary fold. The inner flap is then dissected up, the muscles passing from the trunk to the humerus are divided, and the scapula is dragged away from the chest, and the whole removed by division of the serratus magnus and any remaining soft structure.

This operation occasions considerable shock, and every means must be taken to minimise it.

Amputations in the Lower Extremity

AMPUTATION AT THE INTER-PHALANGEAL AND METATARSO-PHALANGEAL ARTICULATIONS

These operations are performed like those of the fingers (p. 214).

AMPUTATION OF THE GREAT TOE WITH ITS METATARSAL BONE

To facilitate the disarticulation of the base of the metatarsal bone the incision is begun on the inner side of the foot, and is carried on to the dorsum along the line of the tarso-metatarsal articulation, thence down the middle line of the metatarsal bone and opposite the web between the great and second toes the oval is completed (Fig. 92). The soft structure on the inner and plantar aspects are turned aside, the sesamoid bones in the short flexor muscle being left on the bone for removal; the bone is then freed on its outer side, great care being taken that as its base is cleared the knife is kept close to it so that the dorsalis pedis artery be not damaged. The joint is first opened on the inner and dorsal aspects, and the bone is then disarticulated.

Fig. 92.—Amputation of the great toe with its metacarpal bone; of the middle toe at the metatarso-phalangeal articulation; and of the little toe with its metatarsal bone.

AMPUTATION THROUGH THE METATARSUS (HEY), OR THROUGH THE TARSO-METATARSAL ARTICULATIONS (LISFRANC)

Lisfranc's disarticulation is thus performed:—

The foot is held at a right angle with the leg by an assistant, and the surgeon places his finger just behind the projecting base of the fifth metatarsal bone, and his thumb about a finger's breadth farther forwards (*i.e.* a little in front of the tubercle of the scaphoid) on the inner side of the foot to mark the base of the flap. The incision for the plantar flap is carried along the borders of the foot and crosses the sole at the level of the heads of the metatarsal bones. This flap is dissected back, and must include all

the soft structures down to the bones. The foot is now taken by the surgeon and extended, and a slightly curved dorsal flap, about half an inch long, is marked out and dissected up with the deep fascia. The flaps being held well back by the assistant, the surgeon strongly depresses the anterior part of the foot to make the dorsal ligaments tense, and then opens the articulations between the outer three metatarsal bones and the tarsus, next that of the first metatarsal, and finally the second; the last is rather difficult, as the bone is sunk in between the three cuneiforms. The remaining soft structures are divided and the foot is removed.

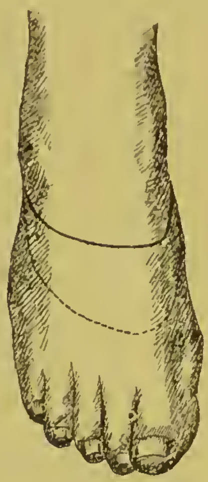


FIG. 93.—Lisfranc's amputation at the tarso-metatarsal articulations.

The flaps for Hey's amputation are made in the same way, but not so far backwards; when they have been reflected the metatarsal bones are sawn through.

AMPUTATION AT THE TRANSVERSE TARSAL ARTICULATION (CHOPART)

In this amputation the whole foot, with the exception of the astragalus and os calcis, is removed. The foot being in the same position as for Lisfranc's operation similar incisions are made, but the base of the flap is farther back. On the inner side the incision is begun well behind the tuberosity of the scaphoid, and ends on the outer side at a corresponding level, *i.e.* just behind the cuboid bone. If the incision is made from the tubercle of the scaphoid and not from a point behind it, the flap will probably not be reflected far enough, and the joint in front of the scaphoid instead of that behind it will be opened; such a mistake is really of no importance, as the scaphoid can easily be removed afterwards. The dorsal flap is similar to that made in Lisfranc's amputation.

FIG. 94.—Chopart's amputation at the transverse tarsal articulation.

SUBASTRAGALOID AMPUTATION

An incision is made from a point one inch vertically below the external malleolus to the base of the fifth metatarsal bone, thence

round the outer border of the foot, across the sole, and up round the inner border opposite the base of the first metatarsal bone, and then across the dorsum of the foot to join the earlier part of the incision just behind the base of the fifth metatarsal bone (Fig. 95).

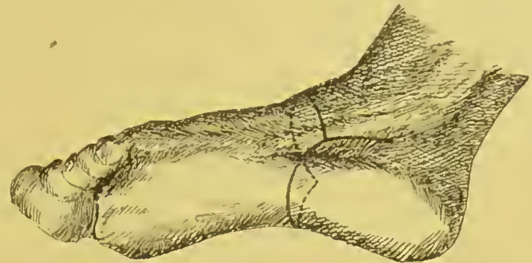


FIG. 95.—Subastragaloid amputation of the foot.

The soft parts on the outer side are dissected up, and the peronei tendons are divided; on the dorsal and inner aspects the flap is reflected to the head of the astragalus; the knife should be kept close to the os calcis on the inner side, so that the vessels may not be damaged. The astragalo-scaphoid joint is opened, and the foot being strongly depressed the knife is passed between the astragalus and os calcis, and the interosseous ligament is divided; by strongly depressing the foot the tendo Achillis is brought into view and divided. The remaining soft structures are separated from the os calcis, and the foot is removed.

PIROGOFF'S AMPUTATION

The foot being held at a right angle with the leg, the surgeon takes a point at the tip of the external malleolus and a corresponding one on the inner side, *i.e.* about half an inch below and behind the internal malleolus. Between these he makes an incision down to the bones across the sole of the foot, sloping forwards at an angle of about 45°.

FIG. 96.—Pirogoff's amputation of the foot.

The foot is then extended, and the joint is opened in front by a determined cut uniting the two ends of the plantar incision. The lateral ligaments are divided by placing the knife between the malleolus and the articular surface of the astragalus, first on one side then on the other. The astragalus is now completely dislocated from the leg, and the upper surface of the os calcis behind it is exposed. This bone is now divided in the line of the plantar skin incision by means of a narrow saw, and the foot is removed. The lower ends of the tibia and fibula are cleared, and the cartilage-

covered surfaces are sawn off. The tendo Achillis is divided, and the sawn surfaces of the os calcis and tibia are united by kangaroo-tendon, ivory pegs, or silver wire. Unless the tendo Achillis be cut, it will tend to displace the piece of the os calcis and draw it upwards and backwards.

SYME'S AMPUTATION

The same guiding points are taken as for Pirogoff's amputation, but the incision is carried somewhat backwards, so that it passes just over and not in front of the tuberosities of the os calcis. The heel flap is dissected up as far as the tendo Achillis, which is divided. In reflecting this flap it should be made tense with the thumb, and the point of the knife should not be lost sight of, or the flap may be damaged. The anterior incision is then made, and the foot is disarticulated by division of the lateral ligaments and any tendons which have not been divided. The lower ends of the leg bones are sawn off.

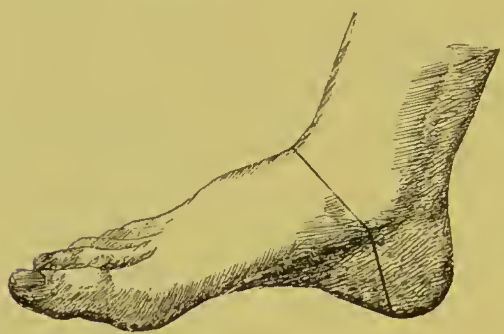


FIG. 97.—Syme's amputation of the foot.

A Syme's stump is exceedingly good, and as the skin covering it is taken from the heel and is well used to pressure, the stump is capable of sustaining considerable weight. This operation is preferable to Pirogoff's.

CONSERVATIVE SURGERY OF THE FOOT

The statements made with regard to the conservative surgery of the hand apply with almost equal force to the foot. When it is necessary to perform primary amputation for injury, the surgeon should look upon the foot as if it consisted merely of one bone, and should not plan his operation according to the articulations which he knows to be present. Whatever can be saved should be saved.

AMPUTATION THROUGH THE LEG

The leg is best removed, especially in the upper third, by lateral flaps (Fig. 98). Teale's amputation by rectangular flaps

(Fig. 99) may be employed low down, but the length of the flap required is so considerable that it is a decided objection to the

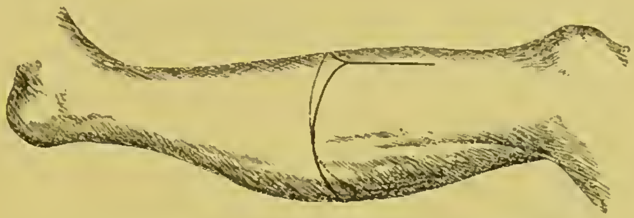


FIG. 98.—Amputation through the leg by lateral flaps.

operation. Farabœuf recommends one long external flap, with circular division of the structures on the inner side by the limb

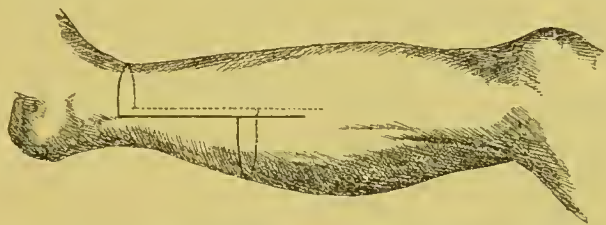


FIG. 99.—Amputation through the leg by Teale's method.

(Fig. 100), some distance below the point at which the bones are to be sawn.

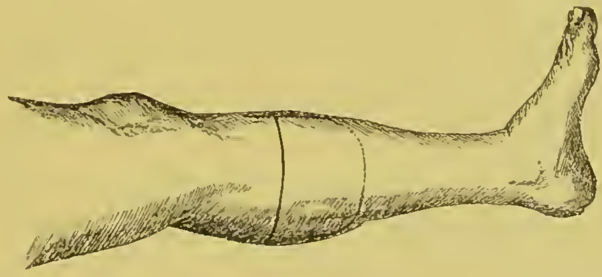


FIG. 100.—Farabœuf's amputation through the leg by long external flap.

The operation by lateral flaps is thus performed :—

The line of the crest and a corresponding point behind being marked by the finger and thumb, a well-rounded flap nearly a diameter in length is cut from either side of the limb. The flaps contain skin and deep fascia only, and when they are fully retracted the muscles are circularly divided ;

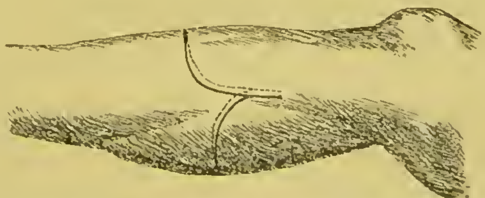


FIG. 101.—Amputation through the leg by antero-posterior flaps.

the interosseous membrane is cut and the bones are cleared. The saw first makes a groove in the tibia, and then, coming on to the fibula, saws both the bones at once but finishes the fibula first.

The sharp edge of the crest of the tibia should be rounded off.

AMPUTATION THROUGH THE KNEE JOINT

Stephen Smith's amputation by lateral flaps is similar to the operation just described for the leg and gives excellent results.

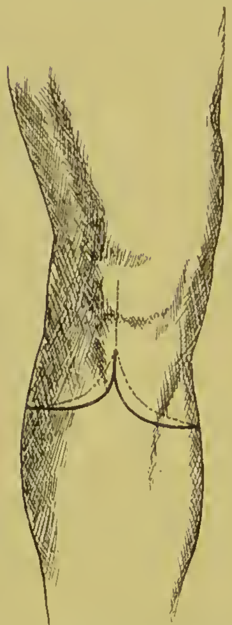


Fig. 102.—Stephen Smith's amputation through the knee joint.

Two well-rounded flaps are cut from a point just above the tubercle of the tibia to a point in the centre of the popliteal space, *i.e.* rather higher up than in front. The outer flap must be nearly a diameter in length, and the inner slightly longer, owing to the projection of the internal condyle. The flaps include the deep fascia, and are dissected up to the level of the head of the tibia; the ligamentum patellæ is divided and the hamstrings are cut. The coronary ligaments which bind the interarticular fibro-cartilages to the head of the tibia are cut through, and the ends of the cartilages are detached, so that these are left on the face of the condyles. The remaining structures are divided by a circular sweep of the knife and the leg is removed.

Fig. 103.—Lister's amputation through the condyles by the modified circular method.

Amputation through the knee may also be performed by a long anterior and short posterior flap, but the latter has a great tendency to retract owing to the presence of the hamstring tendons.

AMPUTATION THROUGH THE THIGH

Amputation through the condyles.—Lister's modified circular amputation (Fig. 103) is performed as follows:—

A circular sweep is made across the anterior half of the leg at the level of the tubercle of the tibia; the ends of this incision are joined behind by a cut running downwards at an angle of forty-five degrees. The skin and deep fascia are turned backwards as far as the upper border of the patella, which will be more easily reached by flexing the knee as the flap is being raised. The hamstring tendons are divided as soon as they are exposed, and when the upper border of the patella has been reached, the quadriceps extensor is cut. The condyles, having been cleared by a circular sweep of the knife, are sawn through transversely to the long axis of the limb so that the sawn surface is level.

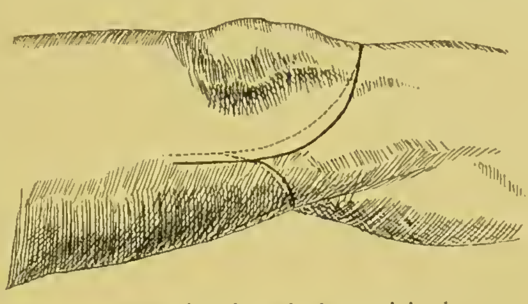


FIG. 104.—Amputation through the condyles by antero-posterior flaps (modified Carden).

Carden's amputation (Fig. 104) by a long anterior and short posterior flap may also be performed, and the patella may be removed or left in the flap.

Gritti recommends that the patella should be left, and its cartilage-covered surface being sawn off, that it should be sutured to the sawn end of the femur.

Stokes of Dublin adopts Gritti's plan, but with the important difference that he saws the bone above the condyles (*supra-condyloid amputation*).

Amputation through the middle of the thigh.—This amputation is best performed by antero-posterior flaps of equal length (Fig. 105), or by an anterior flap equal in length to one and a quarter diameter and a posterior equal to three-quarters of a diameter. At least two diameters of covering must be made, as the contraction of the hamstrings must be allowed for. The posterior flap should not contain muscle, so that the retraction of the hamstrings is reduced to a minimum; but if the limb is small and the muscles are wasted, a little muscle should be taken at the

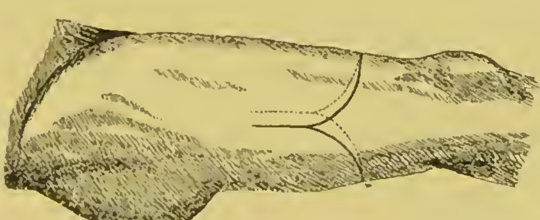


FIG. 105.—Amputation through the thigh by antero-posterior flaps of equal length.

base of the flaps, or the posterior one may be cut by transfixion.

Amputation may also be performed by lateral flaps, or by the circular method if the limb is small. A good deal of trouble is sometimes met with in securing the perforating arteries which retract within the dense fibrous tissue surrounding them. Under such circumstances the vessels may be secured by passing an armed needle beneath them and tying them with the surrounding soft parts (*mediate ligation*).

After the amputation the stump should be bandaged to a pillow so that it is not flexed at the hip, otherwise the flaps are dragged upon and retraction is favoured.

AMPUTATION AT THE HIP JOINT

Hæmorrhage must be prevented by the elastic tourniquet. The band is placed between the anus and tuber ischii, and the ends, one of which passes in front of the groin, and the other over the buttocks, are crossed at the top of the iliac crest, and are then carried round the pelvis and fastened. The band passing in front of the groin compresses the external iliac artery, and that behind secures the vessels of the buttock. To prevent the tourniquet slipping when the limb is removed and the flaps collapse, a stout piece of bandage should be passed beneath the elastic band in front and behind; an assistant dragging on them in an upward direction will keep the band in place. Instead of encircling the pelvis by the tourniquet the ends may be given to an assistant who holds it in position. Digital compression of the femoral is sometimes employed, but will not restrain the hæmorrhage posteriorly, which is chiefly to be feared. Shock and hæmorrhage are the dangers to be specially guarded against.

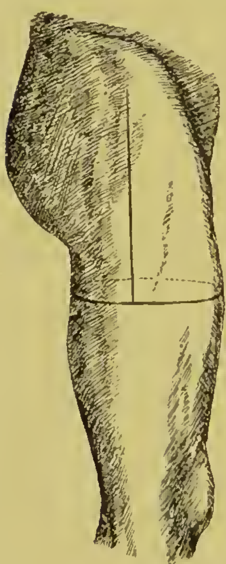


FIG. 106.—Amputation at the hip joint by Furneaux-Jordan's method.

Furneaux-Jordan's method is that most usually performed. The patient is drawn to the edge of the table and is rolled well on to the sound side of the pelvis. As usually described, a circular cut is made at the junction of the middle and lower thirds of the thigh,[1] and the

[1] This gives an unnecessarily lengthy flap, and the incision should be made higher up.

skin and deep fascia are reflected for about three inches as in the ordinary circular amputation; at this level the remaining soft structures are divided to the bone and the vessels are at once secured. A cut is next made on the outer side from a point midway between the iliac crest and the great trochanter to join the circular incision. The limb is rotated inwards and the soft structures are separated from the bone on the outer side; the great trochanter is freed and the exposed part of the capsule is opened. The limb being then rotated outwards, the inner side is similarly dealt with, and when the anterior and inner parts of the capsule have been divided, the head of the femur is dislocated by the assistant strongly adducting the limb, or by external rotation and extension. The knife is then passed behind the head, and the posterior part of the capsule and remaining soft structures are divided from within outwards.

The oval method is similar to Spence's amputation at the shoulder joint, and gives an excellent result. The limb being held in the extended position, the knife is entered midway between the iliac crest and the great trochanter, and is carried down the outer side of the limb nearly to the middle of the thigh, and then the oval is made. Skin and deep fascia only are divided on the inner side, so that the vessels may be left till the last, but on the outer side the cut is made to the bone. The limb is abducted and rotated in, while the outer and hinder parts are reflected from the bone, and the trochanter is cleared. The thigh is now strongly adducted, and when the capsule is divided the head of the femur is dislocated, the inner and posterior parts of the capsule are divided, and the knife is passed behind the head of the bone. The amputation is completed by following the bone downwards until the cut on the inner side is reached, when the muscles and vessels are divided from within out, an assistant having previously compressed the latter in the flap.

Fig. 107.—Amputation at the hip joint by the oval method.

Amputation by antero-posterior flaps cut by transfixion is now rarely performed.

CHAPTER XII

INJURIES OF THE HEAD

HOWEVER slight an injury to the head may at first sight appear, it should never be lightly regarded, for many cases have occurred in which death has resulted from slight blows which caused no immediate symptoms. The importance of head injuries depends upon possible concomitant lesion of the brain or intracranial vessels. In these injuries above all others the surgeon who acts with extra caution will exhibit the greater wisdom.

CONTUSIONS OF THE SCALP

These are usually trivial, but may be associated with simple fracture, concussion, or some other serious condition. Uncomplicated contusions give rise to hæmorrhage into or beneath the scalp, accompanied by swelling and bruising (see Cephalhæmatoma, p. 243). Owing to the plentiful vascular supply the scalp does not slough even after severe bruising.

Treatment.—The application of an ice-bag or evaporating lotion (the hair being removed if necessary) is all that is needed. If any complication is present, the treatment is that of the graver condition.

SCALP WOUNDS

Scalp wounds are exceedingly common, especially among the lower classes. They may be clean cut, contused, lacerated, or punctured, and may be associated with injury to the skull or its contents. The depth and extent of a wound vary; the bone may be stripped of its periosteum and a large flap of scalp may be torn

away and hang down. Scalp wounds bleed freely on account of the numerous vessels present, the denseness of the tissues in which they lie preventing, moreover, their full retraction; the vascularity is, however, favourable to the union of the wound, and prevents sloughing, even when the parts are extensively contused.

Complications.—Apart from concomitant injury which the bone or brain may have sustained, scalp wounds may be followed by serious and sometimes fatal results. Those involving the cranial aponeurosis are especially serious if any septic material is present. If the wound has not been efficiently cleaned, suppuration may ensue locally; and if the discharges putrefy, diffuse cellulitis or erysipelas may follow, causing puffiness and tension of the scalp, with severe constitutional disturbance.

Septic poisoning and infective inflammation are also to be apprehended. If the bone has been exposed and any septic process occurs at the seat of injury, the emissary veins may become thrombosed, and septic osteomyelitis of the diploë is thereby occasioned. In other cases suppuration occurs between the bone and dura mater, beneath the latter, or in the brain itself. The signs and treatment of these conditions will be considered in vol. iii. If septic decomposition of the discharge occurs, and the bone has been denuded by the injury, the outer table may exfoliate, and during this process the patient is open to all the dangers above mentioned.

Treatment.—In all wounds of the head asepsis is of the first importance. The scalp must be shaved for some distance round the wound and thoroughly washed with soap and hot water and a nail-brush; it is then dried and cleansed with turpentine to remove the natural greasiness, then again dried and swabbed over with spirit, after which it is treated with 1:20 carbolic solution. If the edges of the skin flaps are contused and begrimed with dirt so as to prevent thorough cleansing, they should be shaved off, and if the bone is exposed and dirt has been ground into it, the superficial layers should be removed with a sharp chisel and the diploë thoroughly antisepticised with 1:20 carbolic acid or 1:1000 perchloride solution. Hæmorrhage can usually be arrested by pressure firmly maintained for a few minutes; or the larger vessels may be ligatured—though this is not always an easy matter, as they are difficult to secure in the dense tissues of the scalp. If any emissary veins bleed and cannot be checked by pressure, antiseptic carbolised wax should be squeezed into the foramina. Should the bone be denuded, it must be carefully examined for fracture.

The wound, if small and clean cut, should be drawn together by pads of gauze placed on each side and kept in position by the dressing and bandages. If necessary no hesitation need be felt in employing sutures, which should preferably be of horse-hair. Formerly the employment of sutures was condemned on the ground that they excited erysipelas and cellulitis; this they doubtless did, because, the wounds not having been properly cleaned, putrefaction of the discharge ensued and the presence of the sutures prevented its escape. Sutures should be inserted at intervals of about half an inch.

However severe the bruising and laceration of the scalp may be, it should never be cut away (except under the conditions above mentioned), for its vascular supply is so abundant that union readily occurs. A dry antiseptic dressing should be finally applied and may remain untouched until the end of a week or ten days, unless pain, discharge, fever, or any other circumstance renders its earlier removal advisable.

Any complication which may arise must be treated. If fever supervenes and there is evidence of pent-up discharge, some of the sutures must be removed, the discharge evacuated, and the wound cleansed. If cellulitis or erysipelas set in, incisions must be made where necessary, care being taken that they are so placed as to afford free drainage, and do not run in such a direction as to damage important nervous or vascular trunks. Hot boracic fomentations, changed every four hours, and oftener if necessary, should be applied until the inflammation subsides and repair begins. The general treatment is that applicable to similar conditions arising elsewhere (see p. 130, vol. i.).

If a scalp wound is of any magnitude the patient must be kept quiet for some days. Alcoholic stimulants should as a rule be prohibited. The bowels must be kept acting regularly and the diet should be easily digestible and unstimulating.

DIAGNOSIS OF CEREBRAL LESIONS—CEREBRAL LOCALISATION AND TOPOGRAPHY

The diagnosis of a cerebral lesion must be made from two points of view: (1) As to the nature of the pathological change; and (2) as to what part of the brain is affected. In many cases the pathological condition is obvious, but in others it can only be determined by an exploratory operation. The situation of the

lesion, and hence the region of such operation, is determined by a careful analysis of the symptoms which may indicate irritation or destruction of known localised centres.

Irritative lesions of the sensori-motor area excite spasm and convulsions of certain groups of muscles and pain according to the special area involved, the convulsions being on the side opposite to the cerebral lesion.

Destructive lesions cause paralysis and anæsthesia, but the nutrition and electric irritability of the muscles are not affected. If the area destroyed be limited there is monoplegia, but if widespread, hemiplegia results. A destructive lesion may, according to its cause (*e.g.* apoplexy), be primary or, as in cases of tumour, may be preceded by irritative symptoms, the paralysis supervening as the brain is destroyed. If the lesion is of a spreading nature, the muscular area first convulsed as the result of irritation becomes paralysed as the area of primary involvement is destroyed; but neighbouring tracts being gradually involved, other groups of muscles are convulsed in their turn, to become paralysed as the pathological lesion advances.

Although it is true that certain areas of the brain are specially identified with certain functions, yet these areas have no hard-and-fast limits, but gradually pass one into the other, and hence destruction of such an area does not necessarily cause complete paralysis of the muscles over which it presides. Moreover, the different parts of the brain are so correlated that pathological changes at any one part—although the situation is indicated by localising symptoms—may by pressure, interference with the vascular supply, or by raising intracranial tension, affect neighbouring parts or the whole organ.

Cerebral localisation.—Experimental and pathological investigations have proved that certain parts of the cortex of the brain may be mapped out into areas presiding over definite functions; that these areas are not sharply defined but gradually fade away from a centre; that they overlap each other, and that with certain exceptions, which will be more particularly indicated later, the right side of the brain governs the left half of the body and *vice versa.*

The central area of the hemispheres, comprising the ascending parietal and ascending frontal convolutions and the cortex immediately adjacent, is known as the Rolandic or sensori-motor area, its various parts controlling different groups of muscles.

The sensory area of the brain is behind and below the sensori-

motor and includes the posterior part of the parietal, the occipital, and temporo-sphenoidal lobes.

Cutaneous and muscular sense are situated in the motor area,

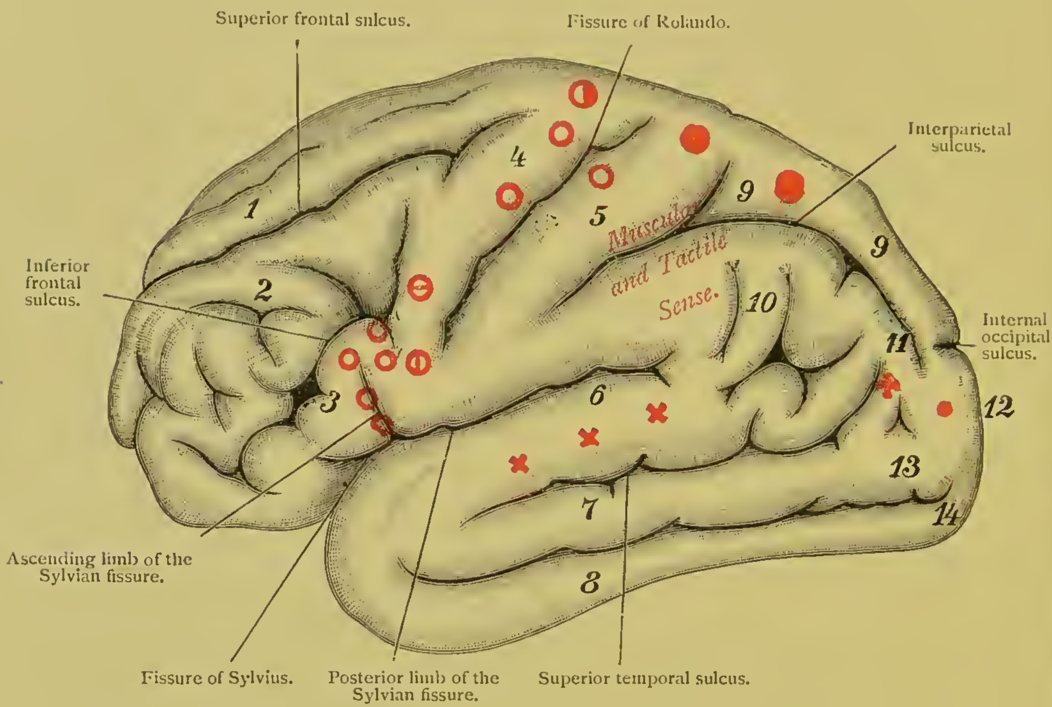


FIG. 108.—Diagram of the cerebral cortex and its centres (Tillmans).

1. First frontal convolution	○ In 4 and 5 on both sides of the fissure of Rolando, motor area for the upper extremity.
2. Second ,, ,,	
3. Third ,, ,,	
4. Anterior central convolution	◑ Motor area partly for the upper and partly for the lower extremity (great toe).
5. Posterior ,, ..	● Motor area for the lower extremity.
	⊖ Cortical area for the facial nerve.
6. Upper temporal ,,	⦶ Cortical area for the hypoglossal nerve.
7. Middle ,, ,,	○ (3) Motor aphasia.
8. Lower ,, ,,	× (6) Sensory (auditory) aphasia with word-deafness.
9. Upper parietal ,,	
10. Lower ,, ,,	+ (11) Aphasia with word-blindness.
11. Angular gyrus.	..
12. Upper occipital ,,	• (12) Region of the visual area.
13. Middle ,, ,,	..
14. Lower ,, ,,	..

and common and tactile sensation in the limbic lobe (gyrus fornicatus and gyrus hippocampus).

The following table indicates the position of the centres and the function over which each presides (Fig. 108):—

Sensori-motor Area

Central convolution.	Upper third.	Movements of the lower limb.
Central convolution.	Middle third.	Movements of the upper limb.
Central convolution.	Lower third.	Movements of the face.
Mesial surface in front of the paracentral lobule.	...	Movements of the trunk.
Second frontal convolution.	Base.	Movements of the head and eyes.
Third left frontal convolution.	Base.	Motor-speech.
Limbic lobe.		Common and tactile sense.

Sensory Area

Occipital lobe and cuneus.	..	Visual centre.
Angular gyrus.	...	Visual speech.
Superior and middle temporo-sphenoidal convolutions.	...	Auditory centre. Auditory speech.
Temporo-sphenoidal lobe—under and inner surface at the tip.	...	Smell and taste.

The senses of smell, taste, hearing, and sight are connected with both cerebral hemispheres, and henee for their total abolition both sides must be damaged. If only one occipital lobe is damaged, there is hemianopsia of the opposite side. If only one auditory centre is affected, deafness is only partial, sinee each ear is connected with both hemispheres. The speeeh eentre is on the left side in right-handed persons, but on the right in the left-handed. It will be noted that we recognise three kinds of speech—motor, visual, and auditory, and that each has its own centre.

If the motor speeeh area be damaged the patient is unable to express himself eorrectly, although he knows quite well what he wants to say (*motor aphasia*); auditory speech confers the power of understanding what is said and of remembering the names of things, but if the centre is damaged the patient can do neither (*word-deafness*); while if the visual speech centre is destroyed, he is unable to understand writing (*word-blindness*, *alexia*).

While the above centres of localisation are proved to exist, there are large tracts of cortical substance whose function is doubtful.

The frontal lobes are probably intimately connected with the mental faculties, and if they are damaged the patient may exhibit evidences of great mental lethargy. The cerebellum presides over muscular co-ordination; vertigo, staggering, and cerebellar ataxia being the chief results of a pathological lesion, especially if the middle lobe is affected.

Cranio-cerebral topography.—In order that the trephine may

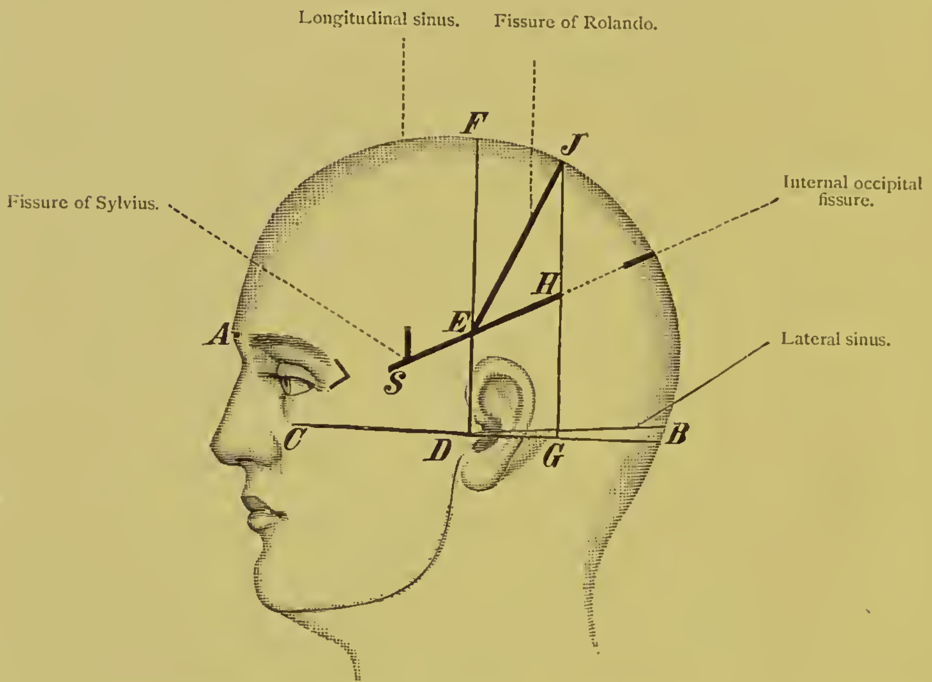


FIG. 109.—Reid's method of determining the position of the fissures of Rolando and Sylvius (Tillmans). *E*, *J*, fissure of Rolando; *S*, *H*, fissure of Sylvius; *C*, *B*, Reid's base line; *A*, glabella.

be correctly applied to the skull, it is necessary to have some exact guiding lines to indicate the position of the Rolandic and other areas.

The upper end of the fissure of Rolando is a little to the side of the middle line of the skull and half an inch behind the mid-point between the glabella and external occipital protuberance. The fissure runs forwards at an angle of 67° and is about $3\frac{1}{2}$ inches long (Fig. 109, *E*, *J*). Horsley's cyrtometer is the most convenient instrument for accurately determining its position.

To find the fissure of Sylvius—

(1) Draw a line from the lower margin of the orbit backwards through the centre of the external auditory meatus (Reid's base line, Fig. 109, *C*, *B*).

(2) Draw a line parallel with the above extending $1\frac{1}{4}$ inch backwards from the external angular process of the frontal bone.

(3) From the hinder end of line 2, draw a line vertically upwards for $1\frac{1}{4}$ inch. This point marks the anterior end of the fissure (Fig. 109, *S*).

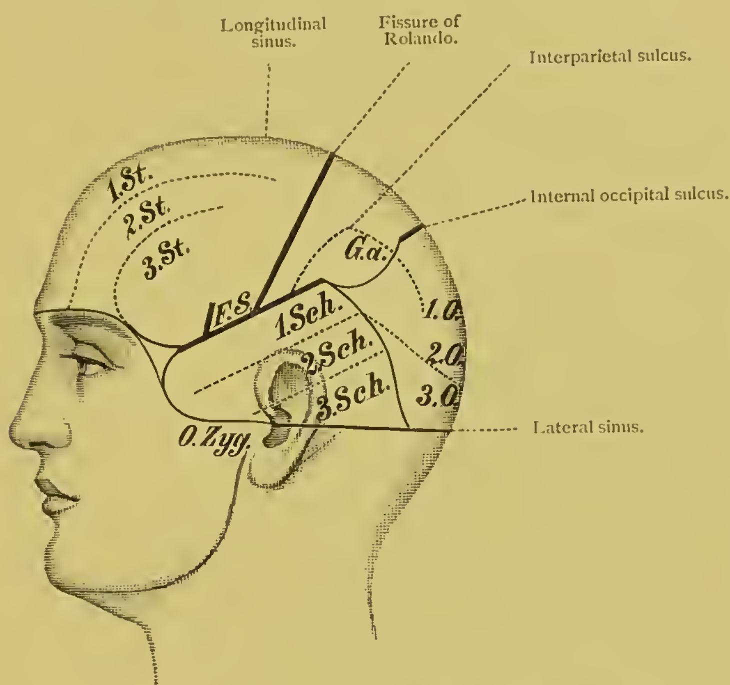


FIG. 110.—Topography of the cortex (Reid). 1, 2, 3 *St*, first, second, and third frontal convolution; *F.S*, fissure of Sylvius; *G.a*, angular gyrus; 1, 2, 3 *Sch*, first, second, and third temporal convolution; 1, 2, 3 *O*, first, second, and third occipital convolution. The basal line runs above the malar bones.

(4) Draw a line backwards from this point for 4 inches, so that the hinder end of it is $\frac{3}{4}$ inch vertically below the most prominent part of the parietal eminence. This point is opposite the posterior end of the fissure (Fig. 109, *H*).

(5) The anterior limb of the fissure is about $\frac{3}{4}$ inch behind the anterior end, *i.e.* 2 inches behind the external angular process of the frontal bone.

To find the parieto-occipital fissure.—Having determined the seat of the Sylvian fissure continue its line back to the mesial plane of the skull, the point of junction will indicate the parieto-occipital fissure (Starr). It is about $2\frac{1}{2}$ inches above the occipital protuberance (Fig. 110).

FRACTURES OF THE SKULL

Fracture of the skull is a common injury and would be more so were the cranium not protected by its shape, thickness, and elasticity, and by the thickness and ready mobility of the scalp overlying it. In the young the pliability of the skull and openness of the sutures afford additional protection.

It will be convenient to discuss fractures of the vault and base separately, but it must be borne in mind that they are often combined.

FRACTURES OF THE VAULT

Causes.—The vertex is broken by direct violence; in so-called indirect fractures, or "fractures by irradiation," in which the chief effects of the violence are at a distance from the point struck, it is found that a fissure always runs from this. It must not be forgotten that a blow upon the head may cause the patient to fall to the ground, or to strike his head against some other resisting object, *e.g.* a wall, either of which may be the fracturing force. If the fracturing force is travelling at a high rate of velocity, the damage is severe but local, but if it be travelling slowly, it is more diffused.

Varieties.—All fractures of the vertex, except the punctured, may be simple or compound.

Fissured fractures are the most usual, and several fissures may radiate from the point struck (*stellate fracture*). A fissure may extend into the base, or may traverse the vertex for a long distance; if it reaches a suture, the line of fracture may pass straight across it, or run down the suture for some distance and pass out on the other side, or be arrested, according to its rate of velocity. Fissured fractures do not cause displacement.

Depressed and comminuted fractures are usually due to great local force. The whole thickness of the bone may be depressed, but may remain attached to the rest of the skull by some spiculæ (*pond-shaped fracture*); or the outer table may be depressed into the inner, which retains its normal level (*gutter-shaped fracture*); or lastly, the inner table may be alone depressed. Such fractures are usually compound.

Punctured fractures are very similar to the last, the only difference being the smaller area of bone involved and the often apparently slight, but essentially serious, nature of the injury. They are always compound.

When the skull is broken, except in the case of simple fissures,

the inner table (provided the force comes from without) is more extensively broken than the outer, and the fragments may, as in punctured fractures, be depressed or displaced between the skull and the dura mater. The greater extent of the fracture of the inner table is due (1) to the diffusion of the force as it is lessened by the resistance of the skull; (2) to the absence of support to the inner table, while it supports the outer; and (3) to its greater brittleness.

Signs and symptoms.—A simple fissured fracture cannot with certainty be diagnosed, although its presence may be inferred from the history of the case, the concussion of the brain, and bruising of the scalp, coupled with some tenderness along the line

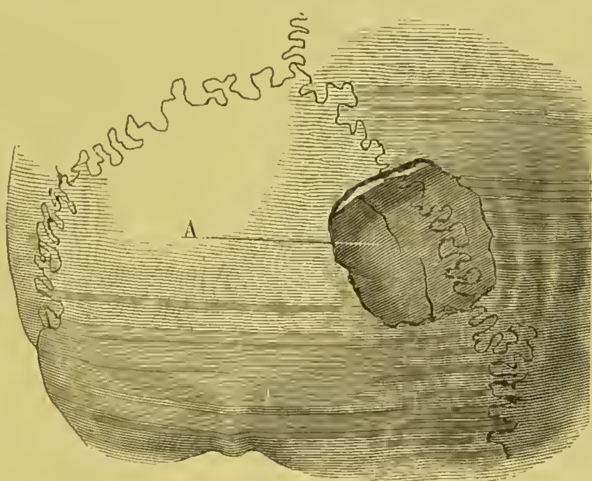


FIG. 111.—Depressed fracture of the skull affecting the occipital and right parietal bones. *A*, depressed bone (Follin).

of fracture. In compound cases the line of fracture is readily seen, blood welling up along the fissure. In the case of depressed and comminuted fractures there is no difficulty in diagnosis, although the former has been confounded with cephalhæmatoma (see p. 243). The scalp wound in punctured fractures may require enlarging to ascertain the real extent of the mischief.

The symptoms likely to be present in any case are not those due to the fracture but to concomitant injury to the brain or meningeal vessels, and at a later date to the possible occurrence of secondary septic mischief in the case of compound fractures. Depressed fractures may or may not be accompanied by symptoms of compression, such symptoms being usually due to the hæmorrhage rather than to the pressure exercised by the depressed fragments of bone (see p. 252).

Prognosis.—If the fracture is uncomplicated the prognosis is good, provided rigid asepsis is ensured in compound cases. In complicated cases the prognosis is rather that of the complication than of the actual fact of fracture.

Treatment.—Simple fissured fractures require practically the same treatment as concussion, the patient being kept at rest for two or three weeks.

In all cases of compound fracture the most rigid asepsis must be observed, the preparatory treatment being that described at p. 231.

As regards **trephining** in cases of fracture of the skull, the general rule to be followed is: To operate in all compound cases where there is depression, comminution, or puncture, whether there be cerebral symptoms or not; but in simple depressed fractures without evidence of compression or intracranial mischief, and if the area of depression is small and the depression slight, the case may be left; it must be carefully watched and operation at once resorted to should symptoms make their appearances. In simple depressed fractures in children whose skulls are very elastic and resilient, trephining may be avoided even when the involved area is large. The disadvantage of trephining in such cases is that the fracture is rendered compound, but if strict asepsis can be assured this is not a matter of great importance; and although non-interference is the general rule in the cases given, it is wiser to trephine in *all* cases; since the danger of sepsis from making the wound compound is, in modern times, much less than that incurred should secondary inflammation or œdema result from the irritation of depressed splinters.

The operation consists in thoroughly exposing the seat of injury and elevating or removing the depressed fragments of bone, care being taken to see that no small and loose fragments are left behind between the skull and dura mater; the bone may be removed by cutting forceps if it be found necessary to enlarge the opening in the skull in order to reach the splinters.

FRACTURES OF THE BASE

Causes.—The base of the skull may be broken by the extension of violence from the vertex, by heavy falls upon the feet, or by direct violence applied through the orbit, nose, or mouth. Fissures of the vertex often pass into the base.

Morbid Anatomy.—The direction of the violence and its point of application influence the seat and direction of the resulting

fracture. If violence be applied to the vertex of the skull transversely to its long axis, the corresponding fossa of the base will be transversely broken; but if the force be in the long axis of the skull, the resulting fissure in the base will also be longitudinal and may traverse all three fossæ (Fig. 112). The middle fossa is more frequently broken than the other two taken together, these being injured in about equal proportion. Most fractures of the base are in reality compound; thus, fractures of the anterior fossa may open the nasal cavity or extend into the pharynx through the body of the sphenoid; those of the middle fossa traverse the petrous bone and open up the tympanic cavity with or without rupture of the membrana tympani. As the violence necessary to cause fracture of the base is greater, so intracranial lesions are more likely to occur than in similar injury to the vertex.

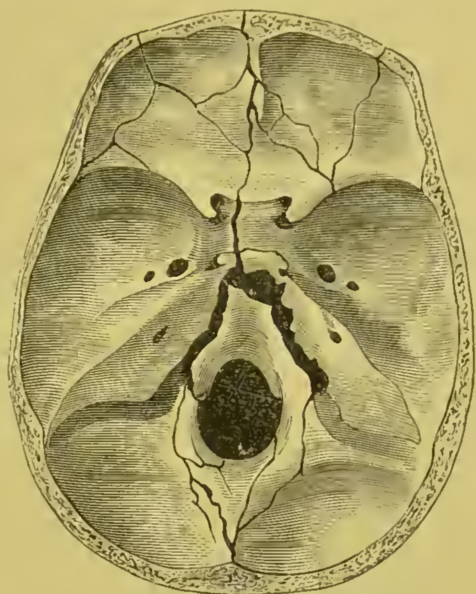


Fig. 112.—Fractures of the base of the skull affecting all the fossæ (Follin, after Trelat).

Symptoms.—The patient is usually deeply concussed, and if there is associated damage to vessels or to the brain, symptoms of compression or irritation will quickly supervene. These symptoms are, however, merely concomitant, and are not in any way indicative of fracture. The signs diagnostic of fracture are the escape of blood and cerebro-spinal fluid, and occasionally of brain matter.

In fracture of the middle fossa extending into the tympanic cavity, the blood may pass down the Eustachian tube and be swallowed or escape from the nose, but more usually there is bleeding from the ear, the membrana tympani being also ruptured. The mere fact of bleeding is not diagnostic, for hæmorrhage may occur from the ear or nose quite independently of fracture of the base; it is the persistence and amount of the bleeding which is characteristic. The hæmorrhage may steadily continue, perhaps for hours, and may not appear for some little time after the injury.

When the anterior fossa is broken the blood may be swallowed or escape from the nose, or, if the orbital roof be broken, it will

pass forwards beneath the lids and conjunctiva; in the latter case the blood comes from behind forwards and has no band of white sclerotic behind it, as is generally the case in hæmorrhage from the sub-conjunctival vessels; the extension forwards takes some time, and the extravasation into the lids is not immediate as in an ordinary "black-eye" unless the orbital margin has itself been damaged.

If the blood has been swallowed, the patient will bring it up when vomiting sets in during the reactionary stage of concussion.

The escape of cerebro-spinal fluid can only occur if the sub-arachnoid space has been opened, and hence this is by no means a constant sign; it argues a severe injury, probably with laceration of the brain, and the prognosis is proportionately grave.

The fluid finds escape from the skull by the same channels as the blood; the flow is continuous, may be very copious, and last for some days. The fluid, unless blood-stained, is watery in character, and contains sodium chloride and a copper reducing substance but practically no albumen, the specific gravity is about 1004.

Brain-matter only escapes in very severe damage, such as gun-shot injuries.

Deafness and loss of smell may result in fractures of the middle or anterior fossa, if the nerves have been damaged. The second, third, sixth, and seventh nerves are less commonly injured. Facial paralysis will be present if the facial nerve has been torn or contused; it may also come on later if the nerve be compressed by blood-clot or becomes involved in callus.

Treatment.—The treatment of fracture of the base of the skull—apart from that of accompanying concussion or compression—consists in the observance of complete rest and quiet, the application of the ice-bag to the head, and the maintenance of asepsis. In all cases it must be remembered that most fractures of the base are compound, that the communication with the air is not freely exposed and is in a situation not easily cleansed, and that hence the risk of secondary infective inflammation is great. When fracture of the middle fossa is compound through the ear, the meatus must be thoroughly cleansed by gentle syringing with boracic solution; the auricle should be lightly dusted with iodoform and covered with a pad of antiseptic wool, but no plug of wool should be placed in the meatus (as is too frequently recommended), since this will prevent the escape of blood or serum. When the fracture is compound into the nose or pharynx, frequent antiseptic douching and spraying, and the use of iodoform are the best means of ensuring cleanliness.

The bowels must be opened with calomel and kept acting by mild aperients; the food must be plentiful and easily digestible, but of an unstimulating character. Absolute and prolonged mental and physical rest is of great importance during convalescence.

Hæmorrhage consequent on Injury to the Head

HÆMORRHAGE OUTSIDE THE SKULL—CEPHALHÆMATOMA

As the result of injury, blood may be effused (1) into the tissues of the scalp, as is frequently seen in the caput succedaneum of the new-born; (2) between the cranial aponeurosis and the periosteum (*sub-aponeurotic cephalhæmatoma*); or (3) beneath the latter (*sub-periosteal*). In the sub-aponeurotic—the most usual form—the blood is generally limited to one parietal bone; it forms a soft, hemispherical tumour, which gradually becomes harder and smaller as absorption of the serum progresses, and is surrounded by a hard, raised, crateriform margin.

Fluctuation is readily felt, and the absence of all head symptoms (although at first there may have been slight concussion) serves to differentiate the case from one of depressed fracture, which, on account of the margin, it may superficially simulate.

Suppuration is rare; but if it occurs, is accompanied by the usual constitutional and local signs of acute abscess.

Treatment.—The patient should be kept at rest, the head shaved over the swelling, and the ice-bag continuously applied. If suppuration occurs, the abscess must be freely opened and the clot turned out under strict antiseptic precautions.

HÆMORRHAGE WITHIN THE SKULL

MIDDLE MENINGEAL HÆMORRHAGE

From its situation, wide distribution, and the thinness of the bone grooved by the vessel, the middle meningeal artery is not infrequently torn across.

In the majority of cases there is associated fracture of the skull, the line of fracture passing across the artery; in a small minority there is no fracture. The force of the injury, whether there be fracture or not, detaches the dura mater from the bone, and hence allows the torn vessel to pour its blood between them. As a rule, the anterior branch or one of its offshoots is the seat of the injury; this point should be remembered in selecting the position for trephining.

The bleeding may, according to the size of the branch and the amount of detachment of the dura, be sudden, profuse, and rapidly fatal, but more usually it is gradual, and the symptoms develop with comparative slowness; the gradual nature of the bleeding is due in part to the resistance offered by the dura, and in part to the enfeebled heart's action accompanying shock or concussion—these latter are, however, not always present. The amount of effused blood varies; on an average it does not exceed two or three ounces, but in some cases may reach eight or nine (Jacobson). The clot is hard and granular, and shelves away at the edges; it is more adherent to the dura mater than to the bone. Both middle meningeals may be injured, and frequently there is ecchymosis, contusion, and laceration of the brain, affecting the under surface of the temporo-sphenoidal and frontal lobes on the side opposite to that struck.

Signs and symptoms.—Immediately on receipt of the injury, the patient may show signs of concussion or collapse; those due to compression by the blood-clot supervene in a short time. If the injury has been slight, the patient, although perhaps temporarily stunned, may show no symptoms for a time varying from minutes to hours, according to the rapidity of the extravasation. This interval of consciousness and absence of symptoms is of the greatest diagnostic value, but unfortunately is by no means constant. As the latter make their appearance, the patient perhaps complains of some pain in the head, a feeling of dizziness, and possibly of nausea; muscular feebleness, gradually increasing in degree, is present, and chiefly affects the muscles of the limbs on the side opposite the injury; a feeling of drowsiness ensues, and culminates in unconsciousness and profound coma. The symptoms described under compression of the brain are present (see p. 253). The pupils are unequal, or are both dilated; in the least severe cases they react to light, but in the more serious they do not. Their state is dependent upon pressure on the third nerve. If the pupil on *that side which has been struck* is dilated, and there are signs of compression, the case is probably one of middle meningeal hæmorrhage; if the dilated pupil is on the *opposite* side, contusion and laceration of the brain is the more probable lesion. If both pupils are dilated, the case may be one of (1) double laceration of the brain, (2) double meningeal hæmorrhage, (3) middle meningeal hæmorrhage on one side and laceration on the other, or (4) a very large clot from one meningeal affecting, by pressure, the opposite half of the brain. It must, however, always be remembered that a dilated pupil ensues from simple injury to the third nerve. The pulse is generally

slow, full, and laboured, but in some cases it is rapid and incompressible. Respiration is usually slow, noisy, and stertorous, but may be rapid; it ceases suddenly before failure of the heart. The temperature is raised one or more degrees; the skin is hot, flushed, and sweating; the sphincters are relaxed, and there is retention of urine from paralysis of the bladder. Unless pressure be relieved, the coma gradually deepens, and death ensues from interference with the respiratory centre in the medulla (p. 253).

Examination of the head may or may not reveal evidence of fracture; there will, however, always be bruising and ecchymosis of the soft structures.

Examination of the limbs may reveal evidence of paresis or paralysis on the opposite side; but it must be remembered that in the state of unconsciousness it is very difficult to clearly make out muscular paralysis. Paralysis in the form of hemiplegia occurs on the side opposite the injury; it is sometimes incomplete, in other cases temporary, or is replaced by convulsive movements or twitchings of groups of muscles, suggestive of associated laceration.

General paralysis is sometimes present, provided there is laceration of the opposite side of the brain, or double meningeal extravasation.

Diagnosis.—In many cases the diagnosis is a matter for doubt; if any exist, the case should be treated by trephining, since with proper antiseptic precautions the operation is practically devoid of danger, and its performance gives the patient the best chance.

From contusion and laceration of the brain middle meningeal hæmorrhage may be distinguished by remembering that contusion occurs on the side opposite to that struck: the dilated pupil will be on the side of the laceration, and any muscular paralysis or convulsive movements on the other side. In laceration there is usually no interval of consciousness after the accident, any such interval being in favour of hæmorrhage.

Extensive hæmorrhage from laceration or from rupture of one of the sinuses (usually the lateral or superior longitudinal) may give rise to symptoms similar to those caused by meningeal extravasation. It must always be remembered in cases of unconsciousness with the history of a fall, that the latter may be the result of the same condition as the unconsciousness itself. It is, of course, of the most vital importance to differentiate such cases (see p. 248).

Prognosis.—Jacobson, in his admirable article on middle meningeal hæmorrhage,[1] divides these cases into three classes:—

(1) Those due to slight violence, in which there is a simple frac-

[1] Guy's Hospital Reports.

ture not extending to the base, with signs of simple compression, but little or no laceration of the brain. These are the most hopeful.

(2) Less hopeful cases, in which the violence has been greater, the fracture having extended into the middle fossa, but in which there is no evidence of marked cerebral injury.

(3) Very great violence, with extensive fracture of vertex and base, and severe associated injury to the brain. These cases are practically hopeless.

In making a prognosis, the suddenness of onset, depth of the coma, and evidence of brain-lesion, are all unfavourable indications. The aged, enfeebled, and debauched are, as in all injuries, especially bad patients. The prognosis in all cases should be given with the utmost caution—most die. The after-treatment consists in perfect and prolonged rest.

Treatment.—In all cases, except those which are obviously hopeless, early trephining should be resorted to. The side of the injury having been determined upon, the trephine should be applied 2 inches above the zygoma, and the same distance behind the external angular process. This is probably the best place; but, owing to the course of the artery, any point may be selected between $1\frac{1}{2}$ to $2\frac{1}{2}$ inches, provided always that the distances from the zygoma and angular process correspond. The scalp is shaved and cleansed, and a semicircular flap is turned downwards towards the zygoma. Before applying the trephine, the exposed skull should be examined for fracture, which, if found, is to a certain extent confirmatory of the diagnosis, but if absent, by no means negatives it; since, as above stated, there may be either no fracture or only such as affects the inner table. As the portion of bone is being removed, blood may well up in the wound, and as soon as the bone is lifted out it usually begins to escape rather freely. Very rarely all hæmorrhage has ceased, and should this fortunately be the case, some of the clot should be removed; it is neither necessary nor wise to remove it all, since by so doing further hæmorrhage is encouraged. Pressure having been relieved, the object of the operation is attained. If hæmorrhage is still going on, many courses are open to the surgeon, the adoption of any of which must be determined by the circumstances of the case. If, as sometimes happens, the vessel is found running in a canal in the bone, such canal should be plugged with carbolised catgut or wax, or a fine cautery point may be inserted. If the vessel can be secured *in situ*, this should be done; if it is still adherent to the dura mater, the clot should be removed, and a ligature, carried through the dura mater by a fine handled needle, should

pass under the vessel, which is thus secured. If ligature *in situ* cannot be accomplished, it is open to the surgeon to follow the ordinary rule of treatment in primary hæmorrhage, viz. to enlarge the wound and tie the vessel; but this necessitates the removal of more bone, and consequent weakening of the skull-cap, and is, moreover, easier in theory than in practice. In default of these methods, the actual cautery may be applied to the bleeding spot, and its use is not fraught with any serious consequences.

If it is found impossible to tie the artery at the bleeding spot, perhaps the wisest course is to apply a freezing-mixture of ice and salt to the side of the head and neck after suturing the skin wound and raising the head. Lastly, there remains ligature of the external or of the common carotid artery, preference being given to the external, since it does not interfere with the *cerebral* circulation.

The brain usually recovers itself completely, but there may be subsequent œdema from the temporary interference with the circulation; should this occur the patient usually dies. In these cases Dean advises that the pia-arachnoid should be incised and the brain allowed to bulge, and that if this be very œdematous it may be itself incised. If the brain does not recover itself, stimulants may be given with the view of encouraging the heart's action and thereby filling the vessels.

HÆMORRHAGE BENEATH THE DURA MATER

When the brain is damaged, blood is effused on its surface, and the delicate membranes may be ruptured so that the blood escapes through the rent. In traumatic cases the patient is concussed as the result of the injury, the symptoms rapidly merging into those of compression. In many cases the patient is beyond help, as the concomitant injury to the skull and brain is severe; in rare cases the damage can be localised, for the pressure of the blood-clot may induce definite symptoms indicative of its position (see p. 233); the surgeon is thus enabled to relieve the patient by trephining, incising the membranes, removing the clot, and securing any vessels which may be found bleeding.

Pachymeningitis hæmorrhagica is described in chap. ix. vol. iii.

HÆMORRHAGE INTO THE SUBSTANCE OF THE BRAIN

In cases of laceration of the brain, the blood is not confined within its substance, but escapes beneath the pia-arachnoid as above stated.

Intra-cerebral hæmorrhage is therefore very rarely the result of injury, but should such a case present itself, and the position of the clot be approximately diagnosed, trephining should be performed.

DIAGNOSIS OF THE CAUSE OF UNCONSCIOUSNESS

It is of the greatest importance that an accurate diagnosis should be made in all cases of coma or partial unconsciousness, for on this depends in great measure the patient's safety and the reputation of the surgeon. If called to such a case, the surgeon should obtain as accurate a history as possible, but must at the same time keep a perfectly open mind, and not allow his judgment to be biassed by what he hears; a history of a fall or accident by no means necessarily indicates that such was the cause of the unconsciousness, for it may have been merely the effect. The fact that a patient has taken alcohol is not evidence that the symptoms he exhibits are due to its influence; he may, on feeling ill, have taken some stimulant medicinally, or even if drunk he may have sustained some independent head-injury, or have been seized with apoplexy.

When there is the least uncertainty as to whether a case is due to alcohol, or to a more serious condition, the patient should always be carefully watched, and given the benefit of the doubt; if this rule were more closely followed, many medical men would have been saved personal regret and public blame.

In most cases the cause of the unconsciousness is quite apparent, but in the small minority the diagnosis is by no means easy, and may be impossible. In all such cases the patient must be carefully examined, and the urine drawn off and tested for albumen and sugar; or if there is any vomiting, the vomit must be examined for evidence of poisons or alcohol. A state of coma or partial unconsciousness may be due to syncope, concussion, compression, apoplexy, embolism, epilepsy, uræmia, diabetes, the acute infective diseases, narcotic poisoning, alcoholism, sunstroke, or exposure to cold and privation. The chief diagnostic features of each of these states will be briefly indicated.

Syncope.—The duration of the unconsciousness is transient, and the patient quickly recovers. The pulse and respiration are feeble, slowed, and shallow, and the skin is usually covered with a profuse sweat.

Concussion and compression, see pp. 250, 253.

Apoplexy.—The coma is profound, and there is evidence of

paralysis. The breathing is stertorous, and the general symptoms are those of compression, but signs of head-injury are usually absent. The urine may be albuminous, since apoplexy is not uncommonly connected with renal mischief. The age of the patient, coupled with evidence of arterial degeneration, is, to some extent, corroborative of the diagnosis.

Cerebral embolism usually occurs in the left middle cerebral artery. The unconsciousness is sudden but lasts only a short time, the symptoms being otherwise practically identical with those of apoplexy. The presence of valvular disease of the heart, or of an aortic aneurism, may aid in the diagnosis, but by no means confirms it.

Epileptic coma is preceded by a definite epileptic attack, to which the patient is usually known to be subject. The lips may be covered with bloody foam, and the tongue lacerated. Unconsciousness is usually of short duration.

Uræmic and diabetic coma occur in persons who are the subjects of renal mischief or diabetes, the evidence of which, in the absence of history, will be found on examination of the urine. The mere presence of albumen or sugar is not, however, certain evidence of the cause of the coma.

The acute infective processes usually present no difficulty.

Narcotic and alcoholic coma may be suspected by the history and gradual onset of the condition; by the smell of the breath, and presence of the drug in the vomit. It is precisely in these cases that so much difficulty arises, and that the surgeon must exercise great caution and judgment.

Opium causes extreme contraction of the pupils, whereas in alcoholic-poisoning the pupil may be found in almost any condition, although in the severest cases it is usually contracted.

Sunstroke and coma from cold and exposure are readily diagnosed by the history.

CONCUSSION OF THE BRAIN

Injuries to the head frequently induce certain symptoms clinically known as "concussion of the brain." The intensity of the condition varies within the widest limits, from temporary giddiness or stunning, to serious collapse, culminating in death. In the more serious cases there is probably some associated damage to the brain, and in those terminating fatally some lesion is constantly found; in the milder cases it may be that similar lesions

are present, varying only in degree. The brain may be found contused and lacerated, and the vessels congested, or there may be minute pia-matral hæmorrhages or patches of ecchymosis in the brain substance (Fig. 113, p. 255). No doubt in severe cases of so-called concussion, the state of the patient is dependent upon these lesions quite as much as upon the mere concussion or shaking of the brain. The pathology of simple uncomplicated concussion is unknown; it has been attributed to arterial spasm and cerebral anæmia, which Duret considers is due to stimulation of the restiform bodies, caused by an increase in the cerebro-spinal fluid in the fourth ventricle. Some have sought to explain the condition by referring it to certain molecular changes in the nervous protoplasm—the result of mere shaking,—whereby its functions are for the time being held in check.

Signs and symptoms.—In the milder degrees of concussion, the patient experiences nothing more serious than temporary giddiness and muscular feebleness, or is for the moment dazed and stunned; he rapidly recovers without any immediate ill-consequences. Such mild cases hardly ever come under the surgeon's notice. In well-marked concussion the symptoms, which may be divided into two stages, appear immediately on receipt of the injury, and after a varying period of time gradually pass off, unless the case proves fatal.

Stage of collapse.—The patient lies as if dead; consciousness may be quite lost, though this is not usually the case—it being possible to rouse him into exhibiting momentary signs of consciousness, from which he quickly relapses. The skin is cold and pale, the temperature depressed 2° or 3° F.; the pulse is slowed, feeble, and almost imperceptible. Respiration is shallow but tranquil, and may be so feeble that the movements of the chest are scarcely perceptible, sometimes it is irregular in force, and occasionally sighing. The pupils are more usually dilated than contracted, but may be either; they are equal and react to light, though slowly. There is extreme muscular feebleness, and reflex action is abolished, or very feeble and delayed; the sphincters may be relaxed, but the urine is retained through inability of the bladder to expel it; its dribbling away signifies that the bladder is over-distended and incapable of holding any more.

The patient remains in this state for a period varying from minutes to hours, the time being proportional to the severity of the injury.

The stage of reaction is ushered in by some slight movement, rarely convulsive; vomiting is present and hastens recovery. The skin loses its death-like pallor, assumes a rosy tinge, and becomes

warm and flushed; the bodily temperature rises, but rarely passes 100° F. The respirations deepen, and are often sighing; the pulse is full, soft, and increased in frequency. With returning consciousness the patient is able to answer questions, but often takes some time to collect his thoughts, and is incapable of mental concentration for any length of time. He is more or less dazed, complains of headache—which may be severe—is very drowsy and often remains in a sleepy condition for some days.

Results and prognosis.—All cases of concussion must be regarded as serious, not so much from any immediate danger as on account of secondary brain disease and impairment of the general health. It is true that in the majority of instances no evil results follow, but in giving a prognosis the minority must not be lost sight of. If unconsciousness lasts for a long time, and symptoms other than those above detailed make their appearance, there is certainly some lesion of the brain complicating mere concussion, and hence the prognosis is more grave. Secondary inflammation of the brain or its membranes sometimes occurs.

Among the more remote effects of concussion we may find constant headache with loss of memory or business habits, inaptitude for work and long mental effort, unnatural irritability of temper, alteration of character and peculiar susceptibility to alcoholic stimulants. Diabetes, epilepsy, and mania sometimes follow. In some cases, although there is no obvious organic mischief, the patient never completely recovers his general health or former "nerve." In all cases the possible occurrence of one or other of these sequelæ must be borne in mind and the risk of their occurrence diminished by judicious treatment and prolonged rest during the period of convalescence.

Treatment.—A patient suffering from concussion should be placed in bed between warm blankets, and hot bottles should be applied to the feet and body. The hot bottles must be carefully enveloped in flannel so that they do not burn the skin. The application of warmth combined with friction, especially over the cardiac area, tends to hasten reaction. In the severer cases, especially if there is reason to suspect any lesion of the brain, the head should be shaved and an ice-bag continuously applied. Rest and perfect quiet in a darkened room are essential. Stimulants should be avoided in all head-injuries, unless the condition of the patient is so serious that he appears likely to die of cardiac failure; in such cases ether should be injected over the heart, or a hot enema of brandy and water administered.

When reaction comes on, the patient must be kept perfectly quiet, and remain in bed for some days, or even for two or three weeks in severe cases. The bowels should be emptied by an enema and kept acting by saline purgatives. The diet must be fluid but nutritious, and given in small quantities. In severe cases, if the patient can afford it, rest—especially mental rest—should be enjoined for some months; excitement of all kinds should be prohibited, and he should be sent away to the country, or for a sea voyage. Prolonged and absolute rest is the best means of completely restoring the health and of averting those mental and other sequelæ already mentioned.

COMPRESSION OF THE BRAIN

Causes.—In many cases the symptoms accompanying compression of the brain are due partly to the actual compression and partly to concomitant injury of the cerebral substance. Concussion is also often present, and therefore the symptoms in any given case, being due to several causes, will present variations in character.

Depressed bone, the presence of a foreign body, or apoplexy, produce the most rapid signs of compression. More gradual onset is due to middle meningeal hæmorrhage, intracranial suppuration, or inflammatory effusion. Tumours and syphilitic or tuberculous deposits induce very gradual compression. In many cases of depressed fracture, the symptoms of compression are due rather to concomitant hæmorrhage and laceration of the brain than to the actual pressure of the depressed bone, as can be demonstrated by the continuance of the symptoms after the elevation of the fragments.

Pathology.—Since the skull is absolutely unyielding, pressure within it must be exerted at the expense of its contents, and this is so, first, at the expense of the cerebro-spinal fluid; secondly, at that of the blood supply. Duret has shown that the cerebro-spinal fluid passes from the lateral to the fourth ventricle, when the cavity of the former is encroached upon by the compressing agent; but since the escape of fluid from the fourth ventricle does not occur as fast as the influx, it is obvious that the intraventricular tension must be raised.

W. G. Spencer and V. Horsley have demonstrated that if the intraventricular pressure is not great, there is an early return to the normal, compensation being effected by increased rate of absorption of the cerebro-spinal fluid and diminished transudation

from the vessels. If, however, the tension rises above a certain level, it will surpass that of the capillary circulation, and hence follows anæmia and consequent functional failure of the cells of the cerebral cortex, and of the gray matter in the ventricular axis, including the nervous centres in the floor of the fourth ventricle. The anæmia is further slightly increased by the direct local pressure exercised by the compressing agent, although this is largely compensated for in the manner above described. As regards the effects of increased pressure in the fourth ventricle, the observers quoted have proved that the very sensitive respiratory centre suffers first and chiefly, and that death is directly due to its paralysis; the cardio-inhibitory and vasomotor centres are quickly affected, their functional activity being perverted or diminished. The stimulation of the cardio-inhibitory centre induces slowing of the heart, followed however by quickening—partly from the advent of compensation, and partly from exhaustion of the centre. The vasomotor centre is similarly first stimulated and then paralysed, and there are consequent alterations in the blood-pressure.

Stimulation of the respiratory centre induces deep and stertorous breathing; but as paralysis sets in the respirations become shallow and irregular.

In consequence of the interference with the circulation already mentioned, œdema of the brain results; and this, which may spread indefinitely, further increases the compression, and thus considerably aggravates the symptoms.

Signs and symptoms.—The signs of compression may be preceded by those of concussion, or may come on some time after an injury, during which interval the patient may be quite conscious. For descriptive purposes it will be well to take a case in which the middle meningeal artery has been ruptured. In such a case the actual force employed in producing the injury may be so slight that the patient feels little more than a stunning at the time of the accident, more usually however he is severely concussed. The symptoms of compression come on after an interval of time, and tend to deepen towards a fatal termination, unless the compressing force be relieved; this is in marked contrast to what occurs in concussion (p. 250). If there has been no preceding concussion, compression manifests itself by pain in the head, muscular feebleness, and gradually increasing drowsiness, deepening to unconsciousness and profound coma. In the early stages the patient is lethargic and semi-conscious; he can be roused for a moment, but quickly relapses, and complete unconsciousness supervenes. The skin is hot,

flushed, and bathed in sweat; the bodily temperature, temporarily depressed, presently rises 4° or 5° F., and if the pressure is unilateral, the surface temperature is higher on the opposite side than on that compressed, since there is vasomotor paralysis of the paralysed parts. There is paralysis, or at least paresis of the muscles in relation with the area compressed, and sensation is similarly affected. Convulsions or muscular twitchings may be present, especially if the brain be lacerated. Reflex action is lost. Respiration is deep, noisy, and stertorous, and is accompanied by blowing out of the lips in consequence of paralysis of the muscles. Towards the end respiration becomes rapid, irregular, and, failing, stops before the heart.

The pupils are unequal and do not react to light; that on the compressed side is temporarily contracted and then dilated. The pulse is full, slow, and laboured; but in bad cases, when the compression is severe, it becomes rapid and irregular from cardiac failure. There is retention of urine, and involuntary evacuation of fæces due to paralysis of the bladder and of the rectal sphincter. Unless the pressure be relieved, coma deepens and ushers in death. It may be spontaneously relieved when the compressing force is fluid, for this may become partly absorbed. In the case of sanguineous apoplexy, partial recovery ensues from the absorption of serum, but the damage due to the pressure of the clot or to actual disruption of nerve-tissue is permanent or but imperfectly repaired. Special symptoms may be developed according to the precise situation of the compressing agent and the effect it has on the brain as regards the integrity of its fibres.

Treatment.—The relief of pressure is the important indication; whether this can or cannot be done by surgical means depends upon its cause, and will be discussed in treating of the various conditions mentioned under causation. The bowels should be opened by purgative enemata, or by a drop of croton oil mixed with butter and put on the back of the tongue. The urine must be drawn off. Absolute quiet is essential.

CONTUSION AND LACERATION OF THE BRAIN

Contusion may occur without laceration, the latter, however, is always accompanied by more or less contusion on which the severity of the symptoms and gravity of the prognosis mainly depend. Direct violence, *e.g.* depressed fracture, causes laceration and contusion at the point of impact, and the membranes are also

often torn. In cases where a severe blow is inflicted on the head without inducing any local damage, the brain may be contused at the side opposite to that struck, owing to its impact against the skull. The situation of contusion or laceration caused by indirect violence depends upon the part of the skull receiving the blow. Blows are most usual on the posterior segment of the skull, and consequently laceration affects the frontal lobes; the apex of the temporo-sphenoidal lobe is often contused owing to the unevenness of the surface on which this part of the brain rests. The occipital lobes, being slung on the smooth and elastic tentorium, are rarely lacerated; the cerebellum lying as it does on the smooth cerebellar fossa also escapes injury. The under surface of the brain is, owing to the irregularities of the base of the skull, more frequently injured than the upper. In cases of compound fracture with laceration of the membranes and the brain, brain-substance may escape from the cavity.

Morbid anatomy.—Contusion may occur alone or may be associated with laceration. It may be diffused or circumscribed the former is rare and dependent upon very severe injury. The injured part may be merely ecchymosed or completely pulped, the pulped brain-substance being mixed with extravasated blood. The amount of hæmorrhage is necessarily greater if laceration is present. Blood may be widely extravasated beneath the pia mater, or may escape beneath the arachnoid or dura mater.

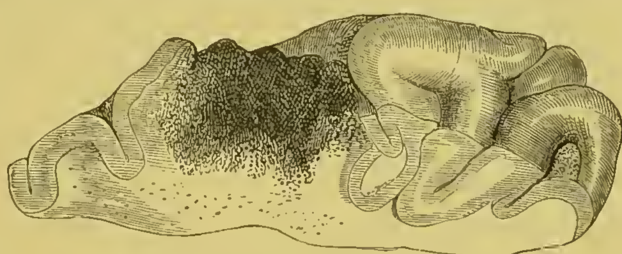


FIG. 113.—Contusion of the brain (Holmes, *System of Surgery*).

The ensuing changes depend upon the severity of the accident. Should the patient recover the effused blood may become absorbed, and the laceration heal in the ordinary way, its situation being indicated by a slight depression of the surface and some staining due to altered blood pigment.

In other cases the blood effused beneath the arachnoid or dura mater gives rise to chronic inflammation leading to the formation of a cyst (see chap. ix. vol. iii.). Secondary inflammatory changes may ensue in the contused part, which softens and becomes covered and infiltrated with exudation of a puriform character; the surrounding vessels are engorged. The inflammation may extend to the membranes and become general.

Œdema and cerebral softening sometimes occur as the result of impeded circulation through the veins, consequent on the pressure of the extravasated blood.

Symptoms.—The symptoms vary according to the seat and extent of the injury to the brain, and the amount of hæmorrhage. In slight cases they are merely those of concussion, the patient recovering without serious harm. The symptoms may be present shortly after the injury or be delayed for four or five days; in the latter case the initial injury is slight, the advent of symptoms being due to œdema consequent upon secondary vascular disturbance. Superficial lacerations do not necessarily cause any diagnostic features, but may do so if certain localising regions of the brain are injured (p. 233). If the bleeding is copious the signs of concussion gradually merge into those of compression, which will, unless relieved, prove fatal. In some cases the peculiar assemblage of symptoms known as **cerebral irritation** is present. The patient lies on his side in a state of general flexion. He is semi-unconscious, restless, sometimes combative, and exhibits extreme irritability of temper. The lids are closed, and any attempt at opening them is resisted; the pupils are contracted. The skin is pale and cold; the pulse small, feeble, and slow; the temperature rises about 2° F. There may be retention of urine, but usually the bladder and sphincters are unaffected. As the symptoms subside—generally in from one to three weeks—the general flexion and rigidity of the body pass off and the patient resumes a normal attitude. The pulse regains its rate and tone, irritability of temper disappears, and the patient either recovers his mental balance or is more dull and stupid than formerly. He is often unaware of the condition through which he has just passed. Convulsive attacks, clonic spasm or rigidity of groups of muscles are very suggestive of laceration; they are dependent upon injury to the motor tracts, and hence vary in situation according to the part of the brain damaged. If the local damage be severe, there is motor and sensory paralysis of the parts presided over by the lacerated area; partial or complete recovery may, however, ensue if the injured tract heals.

The diagnosis of the seat of the injury must be made according to the special symptoms present (p. 233), their severity being a fair guide to the amount of damage.

If any secondary inflammation occurs, the symptoms usually make their appearance about the end of the first week.

Prognosis.—This depends on the extent and seat of the injury to the brain, on the age of the patient, and on the presence or

absence of a fracture of the skull. Such fracture, if compound, involves a more serious prognosis owing to the risk of septic inflammation.

Other things being equal, the prognosis is more favourable in injury of the frontal or upper lobes of the cerebrum, most serious when the pons, crura, or neighbourhood of the medulla is the damaged part.

The younger the patient the better the prognosis. If coma or symptoms of intracranial inflammation supervene, the prognosis becomes very grave.

Treatment.—As in all head injuries, the patient must be kept absolutely quiet; stimulants must be avoided for fear of increasing the hæmorrhage; the bowels must be opened, and food given in such quantities and by such means as the circumstances of the case admit. The head should be shaved and the ice-bag continuously applied. If concussion is present it must be treated; and should signs of compression from hæmorrhage make their appearance, the trephine may be applied over the region indicated by the symptoms; but the operation is, in view of the extent of the damage, of doubtful utility.

Any wound or fracture of the skull must receive attention, every care being taken to ensure asepsis. Should symptoms of compression supervene owing to inflammatory effusion or localised abscess, trephining is indicated.

LACERATION OF THE CRANIAL NERVES

The cranial nerves are usually injured by a fracture passing through their foramina, rarely by the fracturing force itself. Certain nerves are from their position more liable to injury than others. Extravasation of blood pressing on a nerve may cause symptoms similar to those due to injury, but as the blood becomes absorbed these pass off or at least improve. The symptoms occasioned by rupture of any nerve necessarily depend upon its distribution and function.

The olfactory nerve is from its position and softness often torn across in cases of fracture of the anterior fossa, or simply as the result of a severe blow on the head which lacerates the under surface of the frontal lobes. Loss of smell and of taste, so far as the latter is dependent upon smell, is the result.

The optic nerve or chiasma.—If the nerve is torn blindness results. Injury of the chiasma causes interference with vision varying

with the situation of the damage. If one tract is injured, there is lateral hemiopia; if the margin of the chiasma is damaged, there is nasal hemiopia; if the centre, temporal hemiopia results.

The motor oculi, although not usually torn, is often pressed upon by blood-clot, as in laceration of the brain or ruptured middle meningeal artery; in the former case the lesion is on the opposite side to that struck, in the latter on the same side. Within the orbit only one branch may be injured, and the corresponding muscle paralysed. If the main trunk be injured there is ptosis, and paralysis of all the muscles of the globe, excepting the external rectus and superior oblique, which are supplied by the sixth and fourth nerves respectively; the eye, therefore, squints outwards. The pupil is dilated and accommodation is lost, and there is also slight proptosis.

The fourth nerve is sometimes injured, causing paralysis of the superior oblique.

The fifth nerve may be completely lacerated, but more usually only one of its branches suffers. Anæsthesia, motor paralysis, and partial functional palsy of the lachrymal and salivary glands ensue, according to the precise situation of the lesion. In some cases sloughing of the cornea results in spite of every care being taken to protect the globe.

The abducens oculi may be torn in fracture of the base, such injury not being uncommon. Internal strabismus results from paralysis of the external rectus.

The facial nerve is very liable to injury in fractures of the base traversing the petrous bone. Bell's paralysis, *i.e.* of the facial muscles, ensues. If the chorda tympani is involved in the paralysis, the innervation of the submaxillary and sublingual glands suffers.

The auditory nerve is, owing to its softness, more frequently injured in fractures of the base of the skull than is the facial, and deafness results.

The glosso-pharyngeal, vagus, spinal-accessory, and hypoglossal nerves are very seldom damaged.

Treatment.—Injuries of the cranial nerves must be left to the reparative powers of nature. Nutrition of paralysed muscles must be kept up by electric stimulation.

HERNIA CEREBRI

Causes.—When there is an aperture in the cranial vault the brain will protrude, provided there is increased intracranial tension, the protrusion being in itself a means of spontaneous relief. Hernia

does not occur if tension is normal. Small apertures are more likely to favour hernia than are large ones, since the latter afford greater relief if any pressure be present. Increased tension may be due to abscess, intracranial inflammation, œdema of the brain, hæmorrhage, or the presence of a tumour. When hernia cerebri follows an injury, it is due to some form of septic inflammation, and may appear in a few days, or not for some weeks.

Signs.—The size of the protrusion varies with that of the opening, and the degree of increase in the intracranial pressure. The mass may be chiefly composed of inflammatory lymph; it is soft and vascular, and pulsates with respiration. As the hernia increases in size its base becomes compressed by the margin of the opening, and hence congestion, hæmorrhage, suppuration, and sloughing may occur, and septic inflammation spread to the cranial cavity, and further add to the mischief there present. The patient will present symptoms characteristic of the condition which is responsible for the hernia, and the nature of which must chiefly influence the surgeon in making a prognosis and deciding upon the line of treatment.

The great majority of cases die, for, especially in hernia due to injury, septic meningitis or encephalitis is frequently present; even if the patient escapes with life, there may be permanent damage done by destruction and inflammation of the brain area involved.

Treatment.—As hernia cerebri is not a primary condition, but is due to intracranial mischief, its occurrence must be guarded against by the adoption of rigid asepsis in all cases of injury. Should hernia occur, the essential plan is to treat the primary mischief on which it is dependent. Relief may be afforded by still further enlarging the opening in the skull, with the view of diminishing tension, and any cause which is removable, *e.g.* pus or blood, should be removed.

The protrusion itself must be carefully cleansed and protected by antiseptic dressings. The common plan of shaving off the mass and applying pressure to the brain is not only useless but harmful, for the intracranial tension is certainly not thereby diminished, and may be increased.

TRAUMATIC INSANITY

About two per cent of all cases of insanity may be traced to head injury, and in such it has been proposed to apply the trephine to the seat of injury. The most that can at present be said is, that with the onset of the malady such a proceeding may be attended with

success; it would certainly be imperative if there were decided evidence of fracture with depression. If, however, the insanity is of long duration, and the injury very remote, it is highly questionable if operation offers any chance of success. In no case should trephining be performed if there is a family history of insanity.

THE OPERATION OF TREPHINING

Trephining may be called for under any of the following conditions:—(1) Depressed or punctured fracture, (2) foreign bodies within the skull, (3) intracranial hæmorrhage, (4) infective thrombosis of the venous sinuses, (5) intracranial and cerebral suppuration, (6) tumours of the brain or its membranes, (7) traumatic epilepsy, (8) hydrocephalus, (9) traumatic insanity, (10) microcephaly, and (11) persistent headache after injury.

In describing the general performance of the operation it will be convenient to assume that it is undertaken for the removal of a cerebral tumour, its modifications under different conditions being indicated in dealing with these.

Cleansing the scalp.—The day before the operation the scalp should be completely shaved and cleaned in the manner described at p. 231, and it should then be covered with a carbolic or perchloride guard. The lines of the sutures should be lightly marked out on the scalp with an aniline pencil.

Anæsthetic.—Horsley advises that ¼ grain morphine should be injected about a quarter of an hour before the operation, and that chloroform should be used. This enables the patient to do with very little chloroform, and diminishes cerebral congestion and hence hæmorrhage. The shock, which is always great, is consequently lessened.

Position.—The shoulders and head should be well raised.

Incision.—The point at which the trephine is to be applied should be clearly indicated on the skull by driving a sharp instrument through the scalp before any flap is reflected.

The flap should be horse-shoe-shaped, and so placed that the main vessels run up in its base, the knife only dividing their smaller branches.

The scalp must be reflected towards the base, and the bone exposed. Some recommend that the periosteum should not be turned back with the skin, but should be crucially divided.

Opening the skull.—At the point selected a 2-inch trephine is applied, and may be worked with great rapidity and delicacy by a

surgical engine or dental machine. If the circle of bone removed by the trephine be insufficient to expose the actual seat of operation, more must be removed after the periosteum has been further separated. If additional bone is to be cut away, this may be done by a circular saw and engine, by the chisel, or by special cutting forceps (Figs. 114, 115). If it is intended to replace portions of the bone, they should be kept warm in a carbolised sponge.

Opening the dura mater.—This is divided about $\frac{1}{8}$ inch from the margin of the cut surface of the bone, so as to allow of easy suturing later on. The flap should be horse-shoe-shaped, and

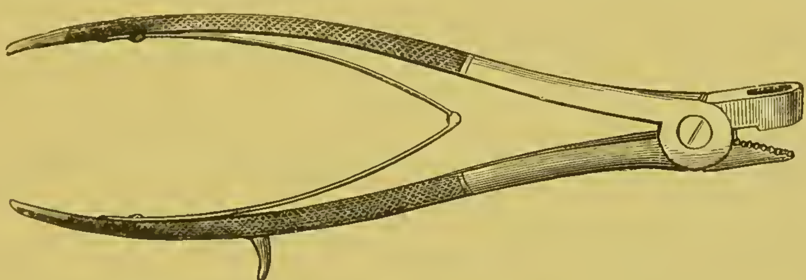


FIG. 114.—Cutting forceps for removing portions of the skull.

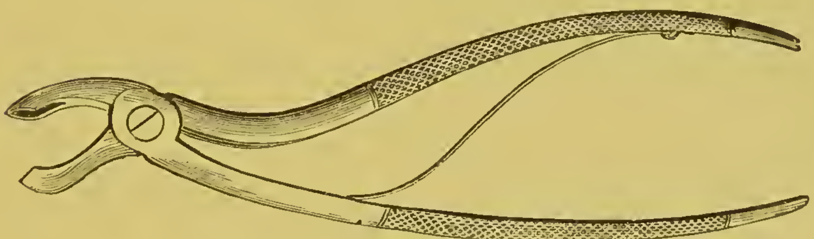


FIG. 115.—Cutting forceps for removing portions of the skull.

reflected downwards. Great care should be taken in reflecting the dura mater, as, if adherent, its separation may cause a good deal of bleeding by rupture of the underlying vessels. Any portion of dura mater which is adherent to an underlying tumour should be itself removed.

The brain.—If, when the dura is reflected, the brain bulges into the wound and is pulseless, this is clear evidence of increased tension. Palpation may show diminution or increase of resistance when abscess or tumour is present.

If a tumour be present, the brain substance is removed for some distance round, and the incision must as far as possible be made perpendicularly, to avoid much hæmorrhage. The brain soon bulges into the seat of operation, so that the gap or depression is very slight.

Hæmorrhage during the operation.—Bleeding from the scalp is easily arrested by firm pressure, or troublesome vessels may be ligatured. Hæmorrhage from vessels lying in canals in the bone may be arrested by plugging the canal with antiseptic wax, or with a piece of chromic catgut. If there is much bleeding from the membranes, the vessels must be secured by a ligature, or failing this, may be touched with the actual cautery. Sometimes a vessel may easily be secured by passing a threaded needle beneath it on one side and bringing it out again on the other. The bleeding from the brain is usually very smart, but can be arrested by moderate sponge-pressure sustained for a few minutes; failing this, a catgut ligature must be carefully applied to the vessel.

Dressing.—All bleeding being arrested, the dura mater is united by a few points of fine catgut suture, and the scalp flap is sutured, about an inch being left open at the most dependent part to permit of free drainage. The question of drainage in cases of abscess is discussed in chapter ix. vol. iii. If it is intended to replace any of the bone which has been removed and kept between warm sponges, small portions are chipped off and placed between the dura mater and the periosteum; but this is never to be done if the operation be undertaken for a condition associated with sepsis.

When the scalp has been sutured, a dry antiseptic dressing is applied and firmly bandaged on. Such dressing may remain untouched for a week or ten days, provided the temperature remains normal, the discharges do not come through, and no symptoms develop which indicate secondary inflammation at the seat of operation; but should any of these conditions arise, the dressings must be changed as often as occasion may require.

CHAPTER XIII

Injuries of the Spinal Column and Cord

Like those of the head, all injuries of the spine must be regarded as serious. Their gravity depends on possible concomitant injury to the spinal membranes, cord, and nerves, and consecutive inflammatory and degenerative changes, rather than on the damage of the bones themselves, although this (especially if associated with considerable rupture of the ligaments) may lead to permanent impairment of strength.

Fortunately, the anatomical construction of the column, and the position and surroundings of the cord, serve in great measure to protect the latter.

Anatomy.—The vertebræ and inter-vertebral discs form an elastic, flexible column of great strength, though allowing of free movement. The whole column presents four curves, of which the dorsal and sacral look backwards and are primary in origin, to allow of increased room for the thoracic and pelvic viscera; the other curves project forwards, and are situate in the cervical and lumbar regions. These are secondarily developed, with the assumption of the erect posture. There is also a normal slight lateral curve to the right in the upper dorsal region. The presence of these curves allows more freedom of movement, and adds much to the strength of the whole column. It has been estimated that the curves of the column make it sixteen times stronger than would otherwise be the case. The weakest point of the column is at the last dorsal vertebra.

The movement allowed between any two vertebræ is slight, but the aggregate movement in the whole column is considerable. Extension is greatest in the cervical and flexion in the lower lumbar region. Force transmitted to the column is diffused through the

various points of contact of the vertebræ, and the elastic discs act as powerful buffers and minimise the effects of jars and injuries.

The spines of the vertebræ, from the sixth cervical downwards, can almost always be felt as they project backwards beneath the skin, and are easily recognisable at the bottom of a groove bounded on each side by the prominence formed by the muscles of the back, which protect the laminæ and transverse processes.

The vertebral canal is enclosed and protected posteriorly by the deep laminæ which overlap one another, and are united by the elastic ligaments. The canal is much larger than the cord which it contains, so that it can be encroached upon to a certain extent without the latter being compressed. The canal is largest in the lower cervical and lumbar regions, where the cord itself presents a definite enlargement.

The dura mater lies within the spinal canal, and is separated from the bones by a plexus of veins embedded in loose cellular tissue; this membrane is separated from the cord by a considerable space, which is filled with cerebro-spinal fluid, and hence the cord is afforded additional protection against injury. The spinal cord extends from the foramen magnum to the lower border of the first lumbar vertebra, and is continued thence as the filum terminale; it is fixed in position by the nerve roots which pass out of the intervertebral foramina, and by the ligamentum denticulatum which passes down between the anterior and posterior nerve roots, and joins with the pia-arachnoid on the one hand, and, at the apices of the denticulations, with the dura mater on the other.

The origin of the nerve roots does not correspond with their escape from the canal, the obliquity increasing lower down until in the lumbar region the nerve cords run vertically downwards in the canal as the cauda equina. The nerve cords are tougher, and hence less easily injured than is the substance of the cord itself.

The cord is completely divided into two halves by the anterior and posterior fissures; the former is wider than the latter, which is, however, much the deeper, although it is not generally regarded as a true fissure.

Conducting paths of the spinal cord.—The spinal cord transmits afferent sensory impressions to the brain, and efferent motor impulses to the muscles; it, moreover, contains centres for reflex action, and presides over certain bodily functions, which, to a certain extent, may be excited or inhibited by the will; the nervous elements are also intimately concerned with the trophic state of the tissues, as is plainly evidenced by the results of injury or disease.

The various conducting paths and centres are not clearly demarcated from each other, but are in close anatomical and physiological relation.

Afferent sensory impulses are conducted by the posterior nerve roots, and pass up on the same side of the cord in the posterior columns. Sensations of pain and temperature pass to the central portions of the gray matter, and muscular impressions pass by the posterior columns, and probably also by the lateral.

Functional impressions (*e.g.* micturition and genital) originating in the lumbar centres ascend along the posterior columns.

Efferent motor impulses cross to the opposite side at the decussation of the pyramids, and pass downwards in the crossed pyramidal tract (posterior part of the lateral column), enter the anterior cornu of gray matter, and pass out by the anterior nerve roots.

Reflexes.—Sensory and motor impulses for reflex actions pass by the same channels as similar impulses, independent of reflex action.

The performance of a reflex act may be impossible if the motor nerve, the sensory nerve, or the centre be damaged. According to Bastian, a reflex may be abolished if the cord above the centre is *severed;* Dr. Head states that reflexes may be exaggerated if the skin at which the sensory impression originates is tender, or if the cord is *partially* damaged above the centre.

The superficial reflexes are those obtained by excitation of the skin. The most important deep, or tendon reflexes are the knee jerk and ankle-clonus, the presence of the latter being pathological.

The reflex centres presiding over the rectum, bladder, and genital organs are situated in the lumbar enlargement, and are controlled by the cerebrum, consequently damage of the paths between the reflex and higher cerebral centres causes alteration in the functional performances of the organs concerned (see p. 278).

Trophic and vasomotor functions of the cord.—That the nervous mechanism plays an extremely important part in nutrition is undoubted, but the nature of such influence is by no means ascertained (see chap. i. vol. i.).

Irritation or damage of the posterior columns, of the cornu of gray matter, or of the posterior nerve-roots, causes skin eruptions, ulceration, sloughing of the skin, and other trophic lesions of the parts implicated, whereas similar mischief in the anterior portions of the cord presiding over the muscular system leads to muscular atrophy and paralysis.

Trophic affections of the joints and atrophy of the bones is induced by disease of the gray matter or posterior columns.

The trophic influence is intimately connected with the vasomotor system, but this cannot be the whole truth in connection with these lesions of nutrition. Vasomotor influences pass from the cord by the anterior nerve-roots.

NEURASTHENIA—TRAUMATIC HYSTERIA—RAILWAY-SPINE—SPINAL CONCUSSION

Etiology.—After any severe injury, but especially such as occurs in railway collisions, a patient, in whom no organic mischief of the nervous centres can be found, may exhibit a peculiar and most diverse train of nervous symptoms extending over a varying period of time, and whose origin is shrouded in obscurity. That mental impression is a powerful factor in producing these symptoms is undoubted, and hence their more common occurrence in nervous, highly impressionable persons and after railway accidents, the circumstances attending which are well calculated to produce profound nervous shock.

Pathology.—Thorburn and Page, whose work has thrown much light on the matter, very properly insist that the symptoms to be presently discussed are dependent upon an impression made upon the whole nervous system, and not upon any one part, and hence that the terms railway *spine* and spinal concussion are inappropriate; the signs formerly classed under the latter term are not thus produced, and spinal concussion may be regarded as one of the rarest of all accidents, even if its occurrence (independently of any organic lesion) can be proved.

Thorburn provisionally adopts the following classification:—

(*a*) *Acute cases.*—Shock or collapse (general nervous depression).
Acute traumatic hysteria (cortical cerebral).

(*b*) *Chronic after-effects.*—Neurasthenia (general nervous depression).
Chronic hysteria (cortical cerebral).

He inclines to the opinion that these conditions (excepting ordinary shock) are analogous with the hypnotic state and auto-suggestion, the determining cause of the former being severe nervous shock, the latter being induced by abnormal sensations provoked by the injury. As regards the paralysis, Thorburn points out that the muscular feebleness and lassitude, consequent on fear or other powerful emotion at the time of injury or other cause, may suggest

to the patient the idea of paralysis, a consequence of railway injury, moreover, which the patient not infrequently anticipates; and by like methods of unconscious suggestion other symptoms may become established.

Symptoms.—It will be clearer to follow the above classification, but it must be remembered that no hard-and-fast line can be drawn between the states. Shock has already been described (see p. 19).

Acute traumatic hysteria.—At the time of the accident a patient may exhibit acute emotional symptoms, such as laughing, or sobbing, or may be actually convulsed; in other cases, he is in a dazed condition, acts mechanically, and although he may perform definitely purposeful acts (*e.g.* help his fellows or walk home), does so quite unconsciously. In such cases the patient may give the most extraordinary and circumstantial account of certain particulars which, according to him, attended the accident, and although such could not have occurred he, nevertheless, tells the story in good faith, for to him it is a fact.

Chronic traumatic hysteria.—Acute hysteria may be followed by paralysis or anæsthesia, or by alteration of the special sensory functions. Paralysis may be replaced by epileptiform attacks, or by spasmodic contraction of groups of muscles, and those of the larynx and bladder may be affected with corresponding changes in the functions of these parts. As regards the sensory system, anæsthesia or hyperæsthesia may be present, and affect half the body or more limited areas. The mental equilibrium may be overthrown and the patient develop melancholia, insanity, or even suicidal tendencies. Defects of vision are common, and the other senses may be affected. The ocular symptoms are sometimes especially prominent, and actual atrophy of the discs may occur. The digestive functions may be deranged probably from interference with the vasomotor centres of the cord. Thorburn records cases of pyrexia, œdema, herpes, and urticaria, and suggests that these may be dependent on vasomotor and trophic influences, consequent on the hysterical condition.

Neurasthenia.—This condition may follow on an injury from which the patient has suffered but little more than slight shock, or he may have exhibited some of the symptoms detailed under Acute Hysteria. Perhaps at the time of the accident he seemed to be quite unaffected and occupied himself with attending to the needs of the less fortunate, but in a day or two he finds that he is not well and has in reality suffered a good deal, or nervous collapse and

shock may supervene as soon as the excitement naturally occasioned by his terrible surroundings has passed off. The individual is "not the man he was"; he is unable to resume his former habits, is incapacitated for business, as he cannot sustain and concentrate his attention; he is easily tired, irritable, intolerant of interruption or noise, moody, depressed, and apprehensive of coming ill. His nervous balance and mental acumen are upset; sleeplessness is a prominent and very distressing symptom, and tends to cause still further mental and physical depression. The appetite is bad, the digestion impaired, the tongue foul, and the bowels confined. Photophobia is often complained of, and the patient is fearful of losing his sight, since his accommodatory apparatus is (owing to the ciliary muscles participating in the general muscular feebleness) incapable of sustained effort, hence he is unable to read for any length of time.

In many cases there is definite complaint of spinal pain limited to two or three vertebræ, but often radiating widely and being accompanied by cutaneous hyperæsthesia. The pain is often associated with rigidity, the result of bruising of the muscles or strain of the ligaments, and not to be mistaken for rigidity consequent on fracture-dislocation or some serious organic mischief. The special functions of the rectal, vesical, and genital centres may be altered. Whatever form the symptoms take, the nervous depression is often made worse by the patient brooding over his troubles, and by the ever-present dread of permanent paralysis from organic mischief which he fears has been overlooked.

Prognosis.—Chronic hysteria and neurasthenia may rapidly disappear, last for many months, or render the patient a chronic invalid.

The symptoms are most likely to persist in neurotic persons, in those who were previously in ill-health, or in the subjects of chronic alcoholism, unfortunately the very class of persons most likely to suffer in the first instance.

Mental anxiety is a powerful etiological factor in prolonging the symptoms, and for this reason the sooner any claim for compensation can be adjusted the better, the worry of legal proceedings and uncertainty as to the result tending to keep up the depressed nervous condition which is at the bottom of the symptoms. It often happens that the settlement of such a claim is soon followed by rapid recovery, and so marked is this that it suggests malingering.

Thorburn notes that in the case of accidents to railway servants

(who cannot claim compensation) he has never met with a case of traumatic hysteria.

The return of natural sleep is a very favourable sign, and complete recovery usually soon follows.

Treatment.—As these conditions are primarily due to nervous depression, and are kept up in many cases by mental anxiety, the treatment to be followed should be of a tonic nature coupled with avoidance of worry.

The patient should not be kept in bed nor confined to a couch, as this will foster the idea that the paralysis and other symptoms are due to organic mischief. If there is any bruising or local injury, this may necessitate confinement for a few days, but as soon as possible the patient should get up. Massage and Faradism must be employed in cases of paralysis, and above all, the patient's mind must be at rest; he should be re-assured as to his condition and encouraged to use his limbs. Cold douching, fresh air, and residence in a quiet country place are beneficial. Plenty of food must be given and tonics must be persevered with. Narcotics should be avoided if possible; but if any, the bromide of ammonia or chloralamide may be given. In hysterical cases it is often a good plan to remove the patient from his friends and place him with strangers.

SPRAINS OF THE SPINAL COLUMN

Sprains and twists of the spinal column may be due to any form of violence which causes sudden wrenching, such as forcible flexion, wrestling, violent gymnastic exercises, and railway accidents.

Morbid anatomy.—The cervical and lumbar regions being naturally the most mobile are the usual seats of the injury. In the simplest cases the muscular and ligamentous structures are merely stretched without laceration of the fibres and the cord is not affected; but when the injury is severe, muscles and ligaments are torn, and hæmorrhage may occur within or without the canal, into the substance of the cord, or along the nerve-roots.

Secondary inflammation of the spinal membranes or of the cord itself may lead to permanent mischief or cause death.

Symptoms.—The severity and duration of the symptoms necessarily vary with the degree of damage inflicted, with the seat of the injury, and the extent of the mischief, if any, done to the cord. The patient complains of having "ricked his back." There is pain which is often severe and much aggravated by movement or pressure on the spine; this leads to marked rigidity of the column.

The patient usually lies on his side, with the knees drawn up; he is absolutely motionless, so that superficial examination may lead the surgeon to diagnose fracture-dislocation with associated paralysis. The pain is often felt over a considerable vertical area, whereas in fracture-dislocation it is usually quite limited. The greater the pain the more likely is it that the muscles and ligaments have been torn, and hence the liability to secondary inflammation is increased. Concomitant injury to the cord or hæmorrhage into its substance or within the spinal canal leads to motor and sensory symptoms similar to those described at p. 278. Hæmaturia is sometimes present in sprains of the lumbar spine from associated bruising of the kidney. As recovery takes place the rigidity of the column gradually disappears, but the patient complains of weakness which may persist for some time.

Prognosis.—The prognosis must always be very guarded, since it is generally impossible to accurately estimate the actual damage inflicted, or to predict the future course of the symptoms until all danger of secondary inflammation of the spinal membranes or cord has passed.

Traumatic hysteria and neurasthenia may complicate or supervene on sprains of the column. In strumous subjects the accident may be followed by caries of the spine.

Treatment.—Absolute rest in the prone position to allow of repair of the injured tissues is essential. Rest should be enjoined until the pain has gone, when the patient will be found to move in bed of his own accord; after this, rest is likely to do more harm than good, especially if the patient shows signs of traumatic hysteria or neurasthenia. Passive motion and massage should be employed, and galvanism may be useful if there is much stiffness. Hot fomentations to the painful region may give considerable relief, but should not be employed if there is any reason to believe that hæmorrhage has occurred into the spinal canal.

PENETRATING WOUNDS OF THE SPINAL COLUMN AND CORD

Punctured and penetrating wounds of the spine are caused by stabs, bayonet and sword thrusts, gun-shot injury, and the like.

Those coming under the care of the surgeon are usually posterior and, in civil life, more often in the cervical region. The small horizontal spines and narrow laminæ of the cervical vertebræ offer less protection to the cord than is the case lower down, and hence wounds in this region are especially dangerous.

Morbid anatomy.—The degree of damage to the bones, ligaments, and cord necessarily depends upon the method of its production; the cord and membranes may escape injury or may be completely crushed, or the former may suffer while the toughness of the dura mater preserves it intact. The fracture of the column is always compound, and portions of the laminæ or the spinous processes may be driven inwards and depressed against the cord. Depressed fragments of bone or a foreign body, even if they do not at the time inflict damage on the spinal cord, may subsequently excite irritation and inflammation. Hæmorrhage may be slight in amount, and the blood escape externally, or being in considerable quantity and poured into the canal, may exert pressure on the contents.

Signs and symptoms.—If there is any doubt as to whether the spinal canal has been opened the wound should be examined with the finger, but a probe must not be used or additional damage may be inflicted. The escape of cerebro-spinal fluid is clear evidence that the membranes have been torn, but its absence does not prove the contrary, since its escape may be prevented by the nature of the wound. The symptoms depend upon whether the cord has or has not been injured, and if so, upon the seat and extent of the lesion (see p. 277), symptoms may also be caused by compression by extravasated blood, or may appear after some days in consequence of secondary inflammation of the meninges or cord.

Prognosis.—The prognosis must be made on the degree of injury which the cord has sustained. The secondary dangers to be apprehended are myelitis and meningitis, and septic inflammation if the wound has been made with a dirty instrument.

Treatment.—The treatment is practically that for fracture-dislocation, in addition to that which the wound demands. If necessary, this must be enlarged, so that it may be thoroughly explored by the finger; and should it be found that the neural arch is depressed, or that a foreign body is present, operative interference is imperative, not only to relieve immediate symptoms, which may be present from pressure on the cord, but also to remove a source of irritation which may subsequently excite inflammation. Rigid asepsis is of course essential, and if the wound is large, or much exudation of serum or cerebro-spinal fluid is to be expected, it must be drained.

If secondary inflammation should occur, and cause compression by inflammatory material, its removal by operation and drainage must be at once undertaken.

FRACTURE-DISLOCATION OF THE SPINE

In the majority of cases fracture and dislocation of the spine are associated injuries; but either may happen alone.

Dislocation without fracture is practically confined to the upper cervical region; fracture without dislocation is more common in the dorsal and lumbar regions, and as the result of direct rather than of indirect violence. The importance of these very serious injuries depends in great measure upon the damage inflicted on the cord, the nerves, and the membranes, and upon secondary inflammatory complications, if the patient survive the immediate effects of the injury.

Fig. 116.—Fracture of the sixth dorsal vertebra. A fragment is driven backwards so that it encroaches upon and narrows the spinal canal (Ziegler).

Causes. — Fracture-dislocation may be caused by direct or indirect violence. When the injury is due to direct violence (by gun-shot injury excepted), the damage is, as a rule, more local and less serious, owing to the fact that the cord may escape or be only partially implicated. Severe blows and falls on the back, buffer-accidents, and gun-shot injury, may be cited as examples of direct violence.

In most cases the violence is applied indirectly, as by forcible flexion of the column, heavy weights falling upon the head or shoulders, and falls upon the nates or heels. The neck may be broken by falls upon the head, especially if the object struck be yielding. Such an accident is not uncommon in the hunting-field.

Morbid anatomy.—The amount of damage varies within wide limits, according to the region of the spine implicated, the position of the fracture as regards any individual vertebra, and its actual cause. Fracture-dislocation by indirect violence usually occurs in the cervico-dorsal or dorso-lumbar regions of the column.

If in consequence of indirect violence the bodies of the vertebræ be subjected to severe twisting or extreme compression, they are

often comminuted and impacted, and portions may be driven backwards into the canal (Fig. 116), the intervertebral discs are more or less torn, and the upper part of the column is displaced forwards on the lower (Fig. 117); but the degree of displacement is very variable. The articular processes are often broken across, and hence dislocation is facilitated; the muscles and soft structures are more or less lacerated and contused, and the ligaments may be extensively torn; the ligamenta subflava and posterior common ligament are frequently ruptured, in consequence of the severe and sudden flexion of the column.

Hæmorrhage varies in amount. Sometimes the membranes, cord, and nerves escape direct damage; but even in such cases serious results may arise, in consequence of hæmorrhage within the canal or of concussion of the cord. More usually, in cases due to indirect violence, the cord is compressed or partially or completely lacerated (Fig. 117). The dura mater may be torn, or may remain intact even when the cord is completely crushed. Individual nerve trunks are sometimes torn. The liability to injury of the cord in the different regions of the column is discussed at p. 277.

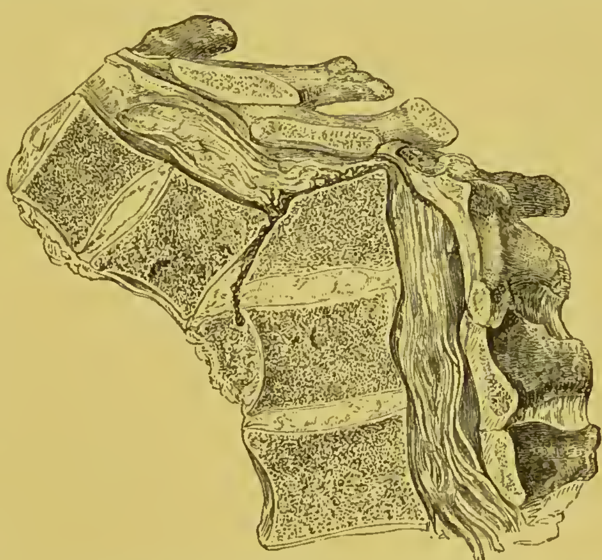


FIG. 117.—Fracture of the spine from indirect violence, passing through the eleventh dorsal vertebra. The theca and cord are torn and the two ends of the latter were separated for one and a half inch. The patient survived eight days (Holmes, *System of Surgery*).

Fracture by direct violence may occur without producing any deformity, or any want of continuity in the column by which its presence can certainly be diagnosed. Severe blows on the back may cause fracture of the spinous processes, or the laminæ may be broken and the neural arch depressed within the canal.

Signs.—The signs of fracture-dislocation may be grouped according to the condition occasioning them: (1) those dependent on shock; (2) those due to the mere fact of fracture and lesion of the column; (3) those which result from implication of the cord or nerves (p. 277).

Shock is always considerable, especially if the fracture is high up and the cord has sustained injury.

In some cases the fracture is so limited that there is no deformity or apparent solution of continuity of the column, and the diagnosis of fracture is merely inferential, the patient exhibiting symptoms such as are met with in sprains of the spine (p. 269). In the more severe cases the patient complains of great pain and tenderness on pressure; and there may be evident mobility at the seat of fracture, with some displacement and irregularity of the spines, and distinct crepitus, or the patient may himself be quite conscious that his back is broken. In most cases he is quite unable to move, owing to the want of stability in the spinal column, and if the cord be damaged there is evident paralysis; there is, especially in cases due to direct violence, more or less bruising and ecchymosis round the seat of injury.

The cord symptoms are detailed at p. 277.

Diagnosis.—In every case of injury to the back, in which it is likely that fracture-dislocation may have occurred, the patient must be moved with the greatest possible care, so that no additional damage may be inflicted on the cord or nerves. He should be moved on a shutter, his clothes cut off, and he must be placed on a water-bed in the dorsal position. When shock has passed off, the column may be gently examined; but if the condition of the patient is evidently hopeless, this is of course unnecessary. As a rule, displacement disappears when the patient is lying on his back; if it do not, gentle manipulation may be of service.

Prognosis.—All injuries to the spinal column are dangerous. The prognosis in cases of fracture-dislocation depends upon the amount of damage inflicted on the cord, and on the situation of the injury. If the cord escapes, and the damage to the bones is not severe, the prognosis is, on the whole, favourable; but it must be guardedly given, in view of possible secondary complications. When the cord is crushed the case usually ends fatally, but in some cases, especially if the damage is low down, the patient may survive for months or even years; the higher up the damage, the more serious the prognosis. Fracture in the cervical region is usually associated with extensive laceration of the cord, and may be fatal immediately, or within a few hours. If the cord in the dorsal region is crushed, the impairment of the respiratory movements is especially dangerous, and the patient will die of secondary pulmonary congestion and overloading of the right side of the heart. Injuries in the lumbar region are more hopeful. Should the patient survive the

immediate effects of the accident, he is very likely to succumb to secondary inflammation (rarely accompanied by suppuration) of the membranes or cord, or from some trophic lesions (especially those affecting the urinary tract), which gradually exhaust the vital powers. If recovery should ultimately result, the paralysis caused by damage to the motor tracts of the cord remains permanent, and leaves the patient bedridden and helpless.

Any injury to the spine may be the origin of tubercular disease, and malignant growths sometimes result.

Treatment.—For the first few days the patient must be kept quite quiet on his back; but at the end of this time, if the case is uncomplicated by severe damage to the cord, he may be encased in a plaster jacket; but this should not be adopted as routine treatment, it being wiser in most cases to rely on perfect rest.

In applying a jacket the patient must be kept lying down, and on no account should he be lifted on to his feet. The jacket may be most conveniently applied, and with the least risk, in the following manner:—Several strips of plastered bandage are prepared and placed on the bed by the side of the patient; there must be enough to extend well up the thorax and below the iliac crests, so that plenty of support is ensured. The patient is carefully lifted on to the prepared strips, which are then made to encircle the trunk in the same manner that a many-tailed bandage is applied; next to the skin strips of soft flannel should first be put on, so that the plaster does not come directly in contact with it. Great care must be taken that the jacket does not cause pressure at any part.

When the cord has been damaged every precaution must be taken to prevent the occurrence of bed-sores. The parts which are exposed to pressure must be kept perfectly dry and clean, the skin should be rubbed with spirit lotion or painted with collodion, and protected from undue pressure by birds'-nests of cotton wool; the sheets must be kept quite smooth and free from rucks.

The catheter must be regularly passed; the best for this purpose is the flexible red rubber instrument, which should be sterilised by boiling before and after use.

Cystitis and bed-sores must be carefully treated should they arise.

Operation.—If the laminæ are depressed on to the cord, an operation is clearly indicated with the view of elevating the bone. In cases in which the cord symptoms are apparently due to pressure of displaced fragments rather than to a crushing lesion, exploratory laminectomy should be performed.

TRAUMATIC HÆMORRHAGE WITHIN THE SPINAL CANAL

Hæmorrhage may accompany a severe sprain without other injury, and is constantly present in fracture-dislocation.

Blood may be effused (1) between the bone and dura mater, (2) beneath the latter, (3) beneath the arachnoid and pia mater, or (4) into the substance of the cord.

Hæmorrhage external to the dura is common, and may be very extensive; it is especially seen in the cervical region. When the bleeding occurs beneath the dura mater the blood often extends a long distance from the injury; blood in this situation may come from the cranial cavity in cases of severe fracture of the base. Hæmorrhage beneath the arachnoid and pia mater is rare; the blood may extend some distance along the nerve-roots and cause considerable pressure on the cord.

Extravasation into the substance of the cord is usually small in amount and localised; this is necessarily the most serious form, since it is accompanied by disruption of the conducting paths.

Symptoms.—In many cases the diagnosis of hæmorrhage is impossible, although the nature of the accident may suggest that the symptoms are due to extravasated blood. If the bleeding is very slight and is outside the cord, there may be no symptoms beyond those due to sprain of the column.

The onset of the symptoms is usually sudden, but in cases where the bleeding is outside the cord, their appearance may be slightly delayed until the blood accumulates in sufficient amount to cause injurious pressure; the symptoms, moreover, become progressively more marked so long as the bleeding continues.

When the hæmorrhage is external to the cord, the symptoms are dependent upon irritation; there are muscular twitchings, with tonic and clonic spasm, and in most cases muscular weakness and paresis, but rarely genuine paralysis. Hyperæsthesia is present, and pain radiates along the nerve trunks. When the hæmorrhage is into the substance of the cord itself the symptoms come on at once, and are dependent rather on destruction than on irritation of the nervous tissue. They are essentially the same as those occasioned by damage to the cord from other causes, and present varieties according to the actual seat and size of the clot. The chief effects are muscular and sensory paralysis, with consecutive trophic changes, notably acute bed-sores and cystitis. The actual seat of the mischief may in some cases be localised by a knowledge of the nerve-root which supplies the paralysed muscles.

Prognosis.—The prognosis in cases of moderate hæmorrhage outside the cord is good, but if the bleeding is large in amount, so that the cord is injuriously compressed, permanent damage or secondary inflammation and degeneration may ensue.

The damage due to actual laceration of the nerve fibres is permanent, but those symptoms which are due to the pressure of the clot will improve as this becomes absorbed.

Treatment.—The treatment is practically that of sprains of the column. Further bleeding may be arrested by the ice-bag and hypodermic injections of ergotine. Stimulants should not be given unless absolutely called for by the general condition of the patient. In cases where it seems probable that the amount of blood-clot is inducing pressure on the cord, laminectomy should be resorted to.

INJURY OF THE SPINAL MEMBRANES, CORD, AND NERVE-ROOTS

The contents of the spinal canal may be damaged by stabs, by gun-shot injury, or by fracture-dislocation. The spinal membranes, on account of the toughness of the dura, often escape, but in severe fracture-dislocation, fragments of bone which have been driven inwards may cause laceration of the dura in addition to or apart from crushing the cord.

The transverse and longitudinal extent of damage to the cord varies within wide limits, depending upon its method of production and the region of the spine affected. In the dorsal region, where the canal is small, the injury is often extensive; in fracture-dislocation of the cervical spine the cord is usually crushed, since there is much displacement, whereas in the lumbar region the size and strength of the vertebræ serve to protect the contents of the canal, and additional security is afforded by the fact that the spinal cord is here replaced by the nerves of the cauda equina, some of which may be damaged, while others escape.

In any region individual nerve trunks may be damaged as they traverse the spinal foramina, independently of any lesion of the cord itself; this is especially likely to occur to the nerves forming the brachial plexus.

Symptoms due to traumatic lesions of the cord.—The symptoms of damage to the cord are of infinite variety, according to the seat and extent of the injury inflicted, and are always associated with considerable shock. When the cord is actually damaged the signs are apparent at once, and in a few days some

modification of the primary symptoms, or the addition of new ones, will result as the outcome of inflammatory changes at the seat of injury, and of degeneration of the damaged nerve-tracts. In some cases of injury to the spinal column without actual lesion of the cord symptoms referable to the latter may come on days, weeks, or months after the injury, and are due to secondary inflammation of the cord or membranes, or to softening, followed by degeneration.

Symptoms due to complete division of the cord—*Effects on motion and sensation.*—There is paralysis (paraplegia) and anæsthesia below the upper limit of the injury. Reflex actions are at first abolished, but in a day or two they return, and are exaggerated; but when myelitis and degenerative changes have advanced, the reflexes become weaker, and finally are permanently abolished.

The acts of defæcation and micturition are essentially involuntary and reflex, but within certain limits are capable of being governed (controlled or excited) by centres in the brain; this dominant influence is necessarily cut off when the cord is completely cut across, and hence these acts are performed independently of any controlling will-power. As the reflexes are at first abolished, there will consequently be constipation and retention of urine with overflow, but on their return, and especially if they are exaggerated, the patient passes his urine and fæces involuntarily and unconsciously. The effect of partial damage of the cord on defæcation and micturition is discussed later. Erection of the penis is another example of reflex action; normally, erection is an inhibitory vasomotor act, the centre for which is in the lumbar cord; in cases of damage above the centre, there is consequent priapism, since the controlling action of the brain is removed. The erection is not complete.

At the upper level of the injury to the cord there is a hyperæsthetic girdle, due to irritation of the lowest nerve arising from the cord above the lesion; this girdle is, owing to the oblique direction taken by the spinal nerves, below the level of the actual seat of damage. Below this painful zone there is complete anæsthesia.

Vasomotor paralysis.—The vessels supplied by nerves arising below the seat of injury are paralysed, and consequently dilated, and the circulation through them is impeded. At first there is paralytic pyrexia of the parts below the injury, but should the patient survive long enough this passes off, and is succeeded by coldness. The impeded circulation may eventually lead to œdema of the limbs and subcutaneous tissue and to slight effusion into the joints.

Trophic changes.—After lesions of the cord certain changes

may occur in consequence of the withdrawal of the trophic influence which we know is exercised by the nerves. That sympathetic paralysis and the defective circulation which it occasions may play some part in producing the trophic changes is probable, but that this is not the chief cause is quite clear. These trophic lesions may and frequently do come on with great rapidity after the accident (in from two to three days), and this rapid onset is incompatible with the view that the changes in question are of purely circulatory origin.

Acute, rapidly extending, gangrenous, and foul bed-sores may make their appearance within a few days even in spite of the avoidance of pressure or other causes which may cause irritation (decubitus ominosus).

Cystitis and pyelo-nephritis are not uncommon. In two or three days the urine may become alkaline, ammoniacal, turbid, and foul; it is loaded with muco-pus and phosphates, and is perhaps bloody; after death the mucous membrane of the bladder may be found ulcerated and sloughy. Similar changes may be met with in the renal pelvis and the kidney itself participates.

It must not be forgotten that cystitis may be excited if dirt be introduced from without by the catheter, the use of which is necessitated by the retention.

Trophic changes, rapid atrophy, and degeneration of the paralysed muscles will occur should the patient survive long enough, and the joints may be the seat of subacute inflammation terminating in fibrous ankylosis.

Symptoms due to partial division of the cord.—Unilateral lesions involving half the cord induce symptoms similar in nature to but differing in distribution from those met with in complete crushes.

More limited lesions produce motor and sensory symptoms referable to the part of the cord destroyed.

There is motor paralysis and loss of muscular sensibility on the same side, and the reflexes are abolished, but shortly return and are considerably exaggerated.

As regards sensation, there will be complete anæsthesia on the opposite side, and also some loss of sensation on the same side; this may be patchy and imperfect owing to the partial crossing of the fibres as soon as they enter the cord. There will be an incomplete zone of hyperæsthesia as in cases of complete division.

Micturition and defæcation are affected as in the case of complete injury; thus if the motor tract alone is damaged and the

sensory remains intact, the patient is quite conscious of the call to perform the acts in question, but has no power to control or augment them; on the other hand, if the sensory tracts alone are damaged, the patient has the power to control or augment the necessary muscular action, but, being unconscious of his need, does not exercise it.

INJURY OF THE DORSO-LUMBAR REGION (ELEVENTH DORSAL TO THE FIFTH LUMBAR VERTEBRA)

As the cord ends at the lower border of the first lumbar vertebra, it may escape injury in fracture-dislocation in the region indicated, and some of the nerves of the cauda equina may escape while others are damaged. Hence paralysis and anæsthesia may be limited to those parts supplied by certain nerves or may be incomplete. The sphincters are relaxed, and at first there is retention of fæces and urine, succeeded by involuntary evacuation; the over-distended bladder is relieved by constant dribbling of urine, which necessitates the employment of the catheter. Trophic changes, bed-sores, acute cystitis, and pyelo-nephritis are common. If the lumbar micturition centre is destroyed, the patient never regains control over the bladder, which becomes atonied, and merely acts as a reservoir devoid of muscular power.

Priapism is not present in cord injuries so low as this region.

INJURY OF THE DORSAL REGION (SECOND DORSAL TO THE ELEVENTH DORSAL VERTEBRA)

The paralysis affects all the parts below the injury, and consequently the muscles of ordinary respiration, with the exception of the diaphragm and those supplied by nerves arising above the lesion, are no longer capable of contraction. The respiration is therefore abdominal and imperfect, especially as regards expiration. Coughing and similar expiratory acts are practically impossible, and hence mucus collects in the bronchial tubes. Circulation in the lungs is impeded and the heart's action is weakened by distension of the right side. Bronchitis and hypostatic congestion will occur if the patient survive long enough. Trophic changes arise, and micturition and defæcation take place involuntarily.

Imperfect priapism is usually present. In determining the seat of the lesion in dorsal injury, it is important to bear in mind that the nerves arise from the cord higher up (about the depth of two vertebral bodies) than they escape from the canal, and consequently

the seat of damage to the cord will be higher up than the zone of anæsthesia.

INJURIES OF THE CERVICAL AND CERVICO-DORSAL REGION (FIRST CERVICAL TO THE SECOND DORSAL VERTEBRA)

Injuries in the upper cervical region are usually immediately fatal; the patient rarely survives twenty-four hours. The most common situation of fracture-dislocation is between the fifth cervical and second dorsal vertebra.

The respiratory difficulty is very marked, the diaphragm being the only muscle capable of contraction. Vomiting and hiccough may be marked, and tympanites occurs in consequence of paralysis of the abdominal muscles. The bodily temperature is usually considerably elevated (even as high as 110° F.), but in some cases it is depressed, and even if high at first, it soon falls if the patient survives. The explanation of these thermometric changes is at present uncertain.

The pulse is usually full but slow (30-40 a minute), and this is probably dependent upon damage to the origin of the spinal accessory nerve and consequent interference with cardiac innervation. The pupil may be contracted in consequence of lesion of the sympathetic. Glycosuria is sometimes present.

COMPRESSION OF THE SPINAL CORD

Causes.—The cord may be compressed by the growth of a tumour within the spinal canal, by inflammatory products or displaced fragments of bone in cases of spinal caries or fracture-dislocation (Fig. 117, p. 273), by inflammatory thickening of the membranes or by blood-clot.

Symptoms.—The area compressed is usually quite limited in longitudinal extent, but all parts below this are necessarily affected by the interference with the conducting paths. Compression is quickly followed by myelitis at the point compressed, and also for some distance above and below this; the myelitis is subacute or chronic, but may at any time become acute. As a result of the myelitis there is softening or sclerosis of the cord which may, however, affect some tracts but little, so that they are, even in bad cases, still able to conduct impulses.

The symptoms of compression vary somewhat with the situation of the lesion, the rapidity of its formation, and the actual degree of

compression; they are dependent (1) upon the actual fact of compression, and (2) upon consecutive myelitis.

There is local spinal tenderness and rigidity, with very severe neuralgic pain and cutaneous hyperæsthesia in the areas supplied by the nerves whose roots are immediately implicated; there may also be disordered sensation,—numbness, tingling, formication, etc., or the painful areas may be interspersed with patches of anæsthesia (anæsthesia dolorosa). After a time there is gradual diminution of sensation, and anæsthesia may even be complete, but this is always preceded by motor paralysis.

In the early stages of compression there may be rigidity, spasm, and contraction of certain muscles or groups of muscles supplied by the nerve-roots which are directly irritated. Sooner or later the contractile power of the muscles becomes diminished in all parts below the seat of compression, and this culminates in complete paralysis; the paralysed muscles slowly or rapidly waste with diminution of electric irritability. The wasting is more rapid and marked when the nerve-roots are implicated.

In the early stages there is an exaggeration of the superficial reflexes and ankle-clonus is present. When the cord as a whole is compressed all parts below the lesion necessarily exhibit the changes described, but if (as in the case of a tumour) a nerve-root is alone pressed upon, the symptoms will be limited to the area of its distribution.

Prognosis.—The prognosis depends upon the actual cause of the compression and whether or not it can be removed by surgical means. If the symptoms are acute and rapidly progressive they are due in the main to myelitis, and hence the prognosis is not so good, although, as the inflammation subsides, considerable improvement will be manifest. In spinal caries complete recovery may ensue, without operation, if an abscess or inflammatory material which is causing pressure symptoms should dry up and shrink so that the pressure is relieved.

Treatment.—The compressing force must be removed when possible by laminectomy and the secondary myelitis treated as described in chapter ix. vol. iii.

CHAPTER XIV

Injuries of the Face, Neck, and Throat

Injuries of the Face

Wounds.—Incised wounds of the face, if properly cleansed and united, heal quickly without deformity. Laccrated and contused wounds may be very extensive, and are accompanied by considerable swelling on account of the laxity of the tissues and the ample vascular supply. The bleeding is usually very free, but is easily arrested by ordinary means. Emphysema sometimes results from implication of the nose or antrum, and the facial nerve or parotid duct may be divided. Wounds of the face may be attacked by erysipelas in predisposed patients; and if the discharges become septic and are pent up, phlebitis may be a serious danger, since the veins are numerous and valveless and communicate with the venous channels of the skull.

Treatment.—Large vessels must be ligatured, and capillary oozing checked by hot water. Styptics are on no account to be employed, as they may excite inflammation and sloughing, causing subsequent deformity. Every care must be taken to ensure perfect cleanliness and the removal of all foreign bodies.

Incised wounds should be very carefully sutured, so that the scarring may be reduced to a minimum. Human hair, thoroughly cleansed in ether, and afterwards in carbolic acid, is an excellent suture, as it can be introduced with the very finest needle; if this is not considered strong enough, horse-hair should be employed. When the eyelid, ear, alæ of the nose, or free margin of the lips have been divided or partially torn away, great care must be taken to ensure accurate apposition. A dry collodion dressing is the best.

Lacerated and contused wounds must be treated on ordinary principles, the employment of sutures and their number depending on the nature and extent of the wound (see p. 13). If the injury has occasioned any loss of substance, a subsequent plastic operation may be necessary.

Wound of the parotid duct is recognised by the escape of saliva externally, especially if a little citric acid is placed on the tongue. The skin wound should in all such cases be very accurately sutured in order that union may occur, otherwise a persistent salivary fistula forms, which causes much annoyance, especially at meal times. The opening on the cheek is quite small, and often presents a small, raised granulation patch. In long-standing cases the opening into the mouth is obliterated, and hence the difficulty of cure increased.

Treatment.—In recent cases the fistula may sometimes be made to close by the application of a fine cautery point, provided the buccal opening is still pervious. If this fails, a fine trochar and canula should be inserted into the external opening and thrust through the cheek in a direction forwards and inwards. Through the canula a piece of silver wire is passed, the end coming out at the angle of the mouth; the other end of the wire is then passed along the duct when the canula has been removed.

By this means the channel into the mouth is restored, and the wire may be withdrawn in two or three weeks; the external opening is made to close by the application of the actual cautery.

FRACTURE OF THE NASAL BONES

Seat and causes.—The nasal bones are broken by direct violence applied from the front or laterally, the direction influencing the resulting deformity. As a rule the bones give way in the lower and thinner half; when broken at the base the injury is more severe, and may be complicated by damage to the nasal process of the superior maxilla, the nasal duct, or the anterior fossa of the skull. The septal cartilage may be displaced.

Signs.—There is always considerable swelling and ecchymosis, and hence the actual occurrence of fracture may remain undetected unless there is marked displacement. As the mucous membrane is usually torn, the fracture is rendered compound; there is bleeding from the nose, and often a good deal of emphysema, especially if the patient has made an attempt to clear away the blood by blowing

his nose. The detached fragment is usually depressed, or if the blow has been laterally delivered, tilted to the opposite side.

Treatment.—Excessive swelling and extravasation will necessitate the use of the ice-bag, but no time should be lost in recognising the existence of fracture and remedying any displacement which may be present, as union occurs in about ten days, and if reposition of the displaced fragment has not been effected, permanent and very unsightly deformity results. Lateral displacement is rectified by external manipulation; but if, as is usually the case, the fragment is depressed, it must be elevated by means of a director passed up the nostril. When once reduced the fragment usually remains in position, and nothing further is needed but the employment of cold. Should there be any difficulty in maintaining good position, the nostril may be plugged with antiseptic gauze, well greased with boracic ointment, a quill being passed through or by the side of the pad for respiratory purposes.

Slight deformity nearly always results.

FRACTURE OF THE MALAR BONE AND ZYGOMA

This accident only occurs as the result of great violence, and is accompanied by fracture of the upper jaw, and perhaps extension into the orbit. There is considerable swelling and ecchymosis, but usually no displacement, although the fragments may be depressed. The nature of the injury is easy of recognition, the examination being aided by placing one finger in the mouth, by which means any depressed fragment may usually be replaced.

Treatment consists in the application of an ice-bag to reduce the swelling and limit extravasation, and the avoidance of all solid food for about ten days.

FRACTURE OF THE UPPER JAW

Fracture of the maxilla is the result of great direct violence, and may be associated with similar injury to the nasal or malar bones, the zygomatic arch, or the anterior fossa of the skull. Any part of the bone may be broken; the alveolar border is sometimes detached, or the outer wall of the antrum driven in. The bleeding is often very profuse, and pieces of bone may remain attached only by slender portions of soft tissue. Even in the worst cases union is rapid and sound, provided due care be taken to replace the fragments and to keep the parts clean.

If the antrum has been opened suppuration may ensue.

Treatment.—No definite treatment applicable to all cases can be stated, but it should be conducted on the following lines:—The fragments should be replaced and not removed unless quite loose; any wound must be thoroughly cleansed, and if the mouth or nose is involved, antiseptic douches and iodoform must be freely used. The diet must be fluid and administered through a tube if necessary. If the alveolar border is detached, loose teeth must be extracted, and the fragment may, if necessary, be fixed by wiring the teeth, or by using a gutta-percha moulded splint.

FRACTURE OF THE LOWER JAW

Seat and causes.—The lower jaw is broken by direct violence, and usually gives way at its weakest part, viz. opposite the canine tooth, and just in front of the mental foramen, the line of fracture being slightly oblique from above downwards and backwards. The alveolar border is sometimes broken off in inexpert dental operations. Fracture of the symphysis in the middle line or of the coronoid process is very rare, but the neck of the condyle is sometimes broken by direct blows on the chin (Fig. 118). It occasionally happens that the fracture is bilateral, the central portion of bone, carrying the incisor teeth, being then drawn downwards.

FIG. 118.—Fracture of the lower jaw to the left of the symphysis—the usual place; and also of both condyles and of the right coronoid process. The injuries were occasioned by a fall from a "great height" (Fergusson).

Signs. — There is considerable pain, aggravated by movement, laceration of and bleeding from the gums, as the fracture is usually compound; there is also some dribbling of saliva. There may be no displacement, and hence no irregularity in the line of teeth; in other cases these are loosened or knocked out and the deformity is marked. Displacement is vertical or lateral; in the vertical form the posterior fragment is drawn upwards and the anterior downwards, the upward displacement being especially marked if the plane of fracture is near the ramus. As a rule the displacement in any direction is but slight. Crepitus can be obtained in all cases.

The inferior dental nerve may be lacerated, but in the great

majority of cases it escapes, partly because the displacement of the fragments is slight, and partly because most fractures are anterior to the mental foramen, and hence not in the course of the nerve. Suppuration and necrosis occasionally result.

Union is usually sound and rapid, but occasionally it fail or is only fibrous.

Treatment.—Any teeth which are seriously loosened may require removal, and if a tooth has been knocked out and is missing, the surgeon should ascertain that it is not wedged between the fragments, otherwise suppuration and non-union may result. In most cases the jaw need only be fixed by means of a four-tailed bandage passing from the point of the chin behind the occiput in one direction, and over the head in the other, and fastened as shown in the diagram (Fig. 119).

FIG. 119.—Outside gutta-percha splint for fracture of the lower jaw (Berkeley Hill).

A gutta-percha perforated splint may be placed beneath the bandage, but can usually be dispensed with. The bandage must be worn two or three weeks, during which time the patient should be fed on liquids introduced by means of a tube passed through an interval between the teeth, or behind the last molar. Talking must be interdicted, so as to maintain complete rest. If the gum has been much torn, it is advisable to use a mouth wash of Condy's fluid or Listerine for the first week.

If there is any difficulty in maintaining the fragments in position and at rest, the teeth may be wired, or some form of interdental splint applied.

If union fails, the propriety of wiring the fragments must be considered. As a rule, the further forwards the fracture the greater is the inconvenience if it remains ununited, while fracture of the ramus does not cause so much trouble, since a false joint is formed near the normal one.

DISLOCATION OF THE LOWER JAW

One or both condyles of the mandible may be dislocated forwards; the injury is bilateral in about 70 per cent of all cases.

Causes.—This dislocation is most commonly met with in women, and is due to muscular action, the external pterygoids drawing the condyles forwards during yawning, laughing, vomiting, etc. It may also occur during the extraction of teeth, or attempts to force large bodies into the mouth.

Anatomy.—The condyles slip in front of the eminentia articularis, and lie on the back of the superior maxillæ or against the malar bones. The capsule is ruptured, or, if naturally loose, is simply stretched, and the external lateral ligament is altered in direction. The temporals, masseters, and internal pterygoids are tightly stretched or partially lacerated, and the external pterygoids and anterior fibres of the masseters are strongly contracted, thus maintaining and fixing the jaw in its new position.

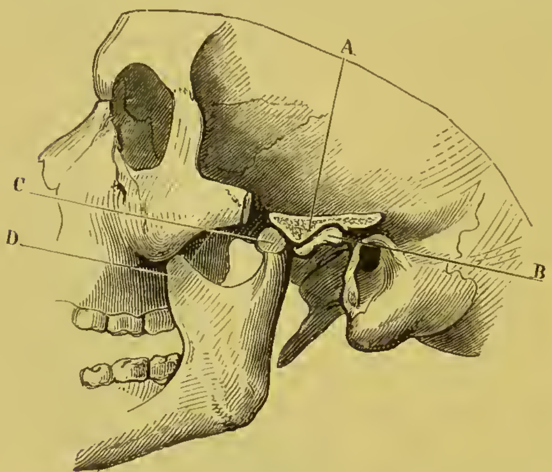


FIG. 120.—Dislocation of the lower jaw. *A*, the sawn zygomatic process; *B*, inter-articular fibro-cartilage; *C*, Condyle of the jaw; *D*, coronoid process (Follin).

Signs.—The mouth is widely open, the jaw fixed, and the chin advanced and depressed. There is a depression in front of the ear, in the normal situation of the condyle, and fulness of the cheek further forwards. Articulation is impossible, deglutition difficult, and saliva dribbles from the mouth. Pain may be considerable from pressure of the condyles on the temporal nerves.

If the dislocation is unilateral, the signs are practically the same as those described; but the chin is directed towards the opposite side of the middle line.

Recurrence of the dislocation is prone to happen from very slight causes.

If left unreduced, movement gradually returns, and the patient can close the jaw, but considerable difficulty in mastication will be permanent.

Reduction.—An anæsthetic is rarely necessary. The surgeon, standing in front of the patient, places his thumbs—protected by lint wrappings—against the crowns of the lower molar teeth, and the fingers beneath the chin. The jaw is depressed by the thumbs, the chin simultaneously raised by the fingers, and the condyle suddenly

slips back into its socket. If any difficulty is experienced, it may be overcome by first slightly depressing the chin to free the condyles, or anæsthesia may be necessary. Reduction under anæthesia may be attempted within eight weeks of the accident.

After-treatment.—The jaw should be fixed by a bandage passing beneath the chin and over the head, as in cases of fracture (Fig. 119, p. 287), and should be kept at perfect rest for from ten to fourteen days, during which only fluid food should be allowed. The patient should be warned of the possibility of recurrence in the future if the mouth be widely opened.

SUBLUXATION OF THE LOWER JAW

In this accident the condyle does not leave its socket, but slips in front of the anterior edge of the interarticular fibro-cartilage; according to some, the accident is due to slipping forward of the cartilage itself, owing to laxity of the ligaments. It is accompanied by a feeling as of something slipping forwards, and by a clicking sound. There may be temporary fixity, but the jaw often slips back again at once. The accident is especially likely to occur in persons whose ligamentous structures are naturally lax, and is due to causes similar to, but less in degree than, those inducing true dislocation. Some persons can produce the displacement at will.

Those who are liable to subluxation should be careful to avoid opening the mouth too wide, since a subluxation is easily converted into a true dislocation. Repeated blistering over the joint is sometimes beneficial.

Injuries of the Neck and Throat

CUT THROAT

Suicidal wounds of the throat are usually met with in men, especially in those who are mentally distressed, or broken down by debauchery or long-continued privation—circumstances which are of great importance as regards prognosis.

Morbid anatomy.—These wounds vary much in depth and character, according to the sharpness of the instrument used and the determination of the would-be suicide. In the most severe cases all structures are divided down to the vertebræ. Simple skin-wounds usually gape widely, on account of the retraction of the fibres of the platysma. Suicidal wounds are usually inflicted in the thyro-hyoid

space, or across the thyroid cartilage; less commonly they extend through the trachea, or are inflicted in the supra-hyoid region. The large vessels of the neck often escape injury, hence the frequent failures to cause death. The comparative immunity of the vessels in any individual case is due to one or more of the following reasons:—

(1) They are deeply placed, and protected by the larynx and sterno-mastoids, a protection all the more certain when the head is thrown back as is usually the case when the injury is inflicted.

(2) The vessels are freely movable, and easily slip aside.

(3) When the air-passages are opened the pectoral muscles lose much of their power, and the arm drops.

(4) The patient's courage fails him before the necessary depth is gained.

(5) Among the uneducated the general belief is that death is occasioned by interference with the air-passages, and hence the suicide's intent is merely to open the windpipe.

It is important to differentiate a suicidal from a homicidal wound, it being remembered that the latter are sometimes intentionally made to resemble the former; the following points of contrast should be noted:—Suicidal wounds are, except in the case of left-handed persons, usually made from left to right in a slightly oblique direction from above downwards; sometimes the wound is transverse. Homicidal wounds may be made in any direction, but are often oblique from below upwards. Suicidal wounds are often much jagged in consequence of the laxity of the skin, and the incision is usually deeper at its commencement than at the end. Homicidal wounds are usually made with greater strength, are more clean cut, and are often deeper at the end. If there are many slight wounds, they are almost certainly suicidal; two or more deep wounds, any one of which would in itself be fatal, are homicidal. In many cases it is difficult or impossible to state the direction of the incision, and the question of suicide or homicide must be determined on other data.

The situation and extent of the wound influence the dangers, both immediate and remote.

If the wound is above the hyoid bone, the pharynx is not usually opened; but the root of the tongue is involved, and there may be severe and even fatal hæmorrhage from the linguals.

The epiglottis may be partially or completely severed in wounds through the thyro-hyoid space, and the superior laryngeal nerves and arteries may be divided, leading to loss of laryngeal sensibility and considerable bleeding. The thyroid cartilage, especially in the

aged, in whom it is frequently ossified, may resist division; but if cut across, the vocal cords are in most cases permanently damaged.

A wound in the lower part of the neck through the trachea is very dangerous, on account of concomitant injury to important vessels.

Dangers and prognosis.—The immediate dangers of wounds of the throat are hæmorrhage, suffocation, and the entrance of air into a divided vein.

Hæmorrhage may prove fatal by its amount, or by the blood entering the air-passages and choking the patient. Profuse bleeding, although not in itself necessarily fatal, lowers the powers of the patient and materially influences the prognosis. Suffocation may be due to the entrance of blood into the air-passages, or to obstruction of the glottis or air-tube by some portion of divided tissue which has fallen out of position, *e.g.* the root of the tongue in wounds above the hyoid.

Œdema of the glottis, bronchitis, pneumonia, and diffuse suppuration with cellulitis are the chief secondary dangers—fortunately, less common than they were, in view of improved methods of treatment. Damage to the vocal cords leads to permanent impairment of speech. Œsophageal and aërial fistulæ are uncommon.

Emphysema may occur if the opening into the air-passage is small, and does not correspond with the wound of the integuments; it is sometimes great, but never constitutes a source of danger.

The prognosis is largely influenced by the condition of the patient, his general health and mental condition being most unfavourable to recovery.

Treatment.—All bleeding must be at once arrested by ligature, and the patient placed in that position which allows of easy breathing. When the wound is quite superficial, it should be thoroughly cleansed and closed, as in a simple skin wound elsewhere. In severe cases the treatment by immediate and individual suture of all divided structures under perfect aseptic conditions should be adopted.

The patient should be anæsthetised, the wound thoroughly cleansed, and each structure which has been divided should be separately and carefully sutured with fine silk, the skin wound being closed and drainage provided at each end for a few days. The strictest asepsis must be adopted. The head is fixed by a cut-throat cap and sandbags, and the dressings are left undisturbed. For the first four days all food should be given by the rectum, a little ice only being allowed by the mouth. Under this treat-

ment primary union may usually be obtained, and the patient is saved the pain and cough occasioned by feeding him through a tube.

Mr. Morris justly claims for this method of treatment the following advantages:—(1) Primary union; (2) avoidance of the trouble and pain occasioned by feeding through the mouth; (3) avoidance of cough and escape of fluid through the wound; (4) prevention of the cicatrisation of the food and air-passages so likely to follow on union by granulation; and (5) prevention of œsophageal or aërial fistulæ.

During treatment the patient must be kept warm and free from draughts, and carefully watched in order that he may not tear off his dressings, or otherwise interfere with the treatment in the hope of terminating his existence. Food and stimulants, with sedatives if necessary, must be given in sufficient quantity. If any of the secondary dangers arise they must receive appropriate treatment; laryngotomy may be necessary if œdema of the glottis supervenes, or if surgical emphysema is extensive.

FRACTURE OF THE HYOID BONE

The hyoid bone may be broken by severe direct violence, as in garotting, the plane of fracture being usually at the junction of the body and great cornu. The smaller fragment is displaced inwards, and may wound the mucous membrane of the pharynx, a complication indicated by bloody expectoration. There is some cough and swelling, and considerable pain on movement of the tongue. The nature of the accident is readily diagnosed by external examination, combined if necessary with digital exploration through the mouth. Crepitus can be detected when the patient swallows.

Treatment.—The neck must be kept quiet by surrounding the head with sandbags. Movement of the tongue should be reduced to a minimum, and hence the patient must not be allowed to talk, and should be fed by the rectum for a few days, a little ice only being given by the mouth. When food is given by the mouth it should be of a fluid nature until the fracture has healed.

FRACTURE OF THE THYROID CARTILAGE

The thyroid cartilage is broken in the same manner as is the hyoid bone. Most surgeons consider the accident to be more common in the aged when the cartilage is ossified, but Hamilton

denies this, and says that the brittleness and liability to fracture is as great when the thyroid is purely cartilaginous. External examination will reveal the nature of the injury, which is attended by considerable swelling and pain, weakness of the voice, or complete aphonia, and difficulty in respiration, with cough and bloody expectoration. Emphysema of the neck is sometimes seen, and œdema glottidis may come on within a few hours.

Treatment is practically the same as that given for fracture of the hyoid bone. Cold must be applied to the neck, and should œdema of the glottis supervene, tracheotomy may be necessary. Some impairment of the voice will be permanent.

It has been proposed to cut down upon and wire the fragments, but in ordinary cases such a procedure is not to be recommended.

FRACTURE OF THE CRICOID CARTILAGE AND TRACHEA

This accident is occasionally met with as the result of great violence. There is great embarrassment of respiration, with cough and bloody expectoration. Swelling of the neck is considerable, and there may be much emphysema. If the respiratory difficulty or emphysema is great, tracheotomy may be necessary. This injury is very dangerous, and usually fatal.

INJURIES OF THE ŒSOPHAGUS

Wounds.—The œsophagus may be wounded from without by stabs, attempts at suicide, gun-shot injury, and the like, or from within, as in the case of "sword-swallowing," or rough attempts to pass a bougie in cases of stricture when the walls are probably weakened by ulceration. Wounds from within, and those involving the thoracic portion, are the most serious, and are usually complicated by some other injury, *e.g.* wound of the heart or great vessels, which may prove immediately fatal. The nature and extent of the wound necessarily vary with the method of its production; generally speaking, longitudinal wounds are less serious than transverse, since, as they gape less, there is consequently less liability for food to pass into the surrounding parts, and they heal more readily.

Signs.—Wounds in the cervical region may be quite obvious unless they are very small and punctured, in which case they may remain undetected until cellulitis is set up by the escape of food.

Wound of the thoracic portion is indicated by extreme collapse,

and the usual signs of grave internal mischief, perhaps, with evidence of complications.

In all cases there is pain, great thirst, and sometimes vomiting, the vomited matters being mixed with blood; cough and dyspnœa are also present.

Cellulitis is to be apprehended if the patient survives long enough.

Treatment.—Wounds of the cervical portion should be freely exposed, and if possible sutured, but the wound in the soft parts leading down to the œsophagus must be plugged with gauze and left to granulate from the bottom. The head should be fixed, and the neck slightly flexed. Feeding must be by enemata or through an œsophageal tube retained in position for a few days. Occasionally an œsophageal fistula is left. Wounds of the thoracic portion cannot be closed; the patient must be kept quiet and fed by the rectum; mediastinitis, or some complication, is usually rapidly fatal.

RUPTURE OF THE ŒSOPHAGUS

Rupture occasionally occurs from very severe vomiting, or in consequence of ulceration following the impaction of a foreign body, cancer, or the action of corrosive poisons. The leading signs are collapse, thirst, vomiting, hæmatemesis, and emphysema. Death almost always results. If the cervical portion is the seat of rupture, an incision must be made down to the injury, the parts must be cleansed, and free drainage secured. Attempts to suture should not be made in view of probable disease of the walls. Rupture of the thoracic portion is usually undiagnosed, and not amenable to surgical interference.

THE EFFECT OF CORROSIVE POISONS WHEN SWALLOWED

The mineral acids, caustic alkalies, and other corrosive poisons, when swallowed, produce serious destructive changes on the tissues with which they come in contact. The angles of the mouth, lips, tongue, cheeks, the pharynx, fauces, and mucous membrane of the œsophagus will show evidence of burning. The stomach is similarly and often more seriously affected. The mucous membranes are shrivelled and corroded, and in the œsophagus the membrane is much wrinkled. Large shreds may be detached, and the caustic affecting the muscular coat may cause perforation or so weaken the wall that it is easily lacerated, as in the act of vomiting. Perfora-

tion is most usual from the mineral acids, and is rarely seen except at the fundus of the stomach; if it occurs, the acid will escape into the peritoneal cavity and exert its corrosive effects on its contents. If the amount of poison taken is small and remedies are at once used, or if it be taken in a diluted form, the patient may recover, but ulceration with consecutive contraction may lead to serious results from stricture (chap. xvii. vol. iii.).

The mucous membranes are acutely inflamed and frequently studded with hæmorrhagic areas. The surface is, in many cases, stained by the poisonous fluid, or by the precipitation of some salt. Sulphuric acid produces a dead white colour, soon becoming deep brown or black from altered blood pigment; carbolic acid stains white, hydrochloric brown, nitric yellow or green, oxalic white mixed with brown mucus, antimony white, copper green, corrosive sublimate white or slate-coloured from precipitation of the salt, nitrate of silver white from precipitation of the chloride.

Symptoms.—The history or the discovery of the bottle which contained the poison, coupled with the condition of the lips and mouth, is sufficient evidence. The patient suffers intense burning pain along the œsophagus and in the abdomen. There is bloody vomiting, and some of the poison is brought up, and hence the vomited matter should always be kept for future examination. There is extreme dysphagia, moderate dyspnœa, and the patient speedily succumbs in a state of general collapse.

Treatment.—In cases of corrosive poisoning the stomach-pump should never be used for fear of rupturing the damaged œsophagus. A full dose of apomorphia must be at once given, or vomiting ensured by the use of some emetic ready to hand. Water, lime-water, chalk, and dilute alkaline fluids should be given in large quantities in poisoning by the mineral acids, and dilute acid solutions when a caustic alkali has been taken; this should be followed by white of egg or egg and milk.

Pain necessitates the free use of opiates. Food and stimulants must be given by the rectum, and all food withheld by the stomach for some days.

FOREIGN BODIES IN THE ŒSOPHAGUS

Foreign bodies of the most diverse nature[1] may become impacted (1) just behind the cricoid cartilage; (2) opposite the

[1] The following have been met with (Ashurst's *Encyclop. Surg.* vol. vi. p. 8). The common ones are printed in italics:—Leeches, fishes, salamanders, mice, eels, frogs, ascarides, tæniæ, hydatids; beef-bones, *fish-bones*, *other food-bones*, nasal

bifurcation of the trachea; (3) or near the cardiac end, the first being the usual situation. Impaction behind the cricoid may cause pressure on the trachea, which may be immediately fatal. If the foreign body is not removed, or does not pass into the stomach (see p. 340), it may remain for a long time without causing much harm, or may excite inflammation and ulceration of the walls and be thus discharged into the surrounding parts, *e.g.* the trachea. Sharp bodies, such as needles or fish-bones, may perforate the œsophagus and enter the pericardium or large vessels with a fatal result; needles sometimes pass out and subsequently work their way to the surface at some distant part, without exciting any mischief during their passage.

Signs.—The history may reveal the nature of the accident, but especially in young children is often negative. If there is pressure on the trachea, dyspnœa and even asphyxia results. The patient complains of dysphagia and pain, which often enable him to accurately localise the position of the body, which, if large, may form a distinct prominence in the neck. Vomiting is frequent, and may result in spontaneous expulsion. The passage of a bougie will usually detect the foreign body, and if it is small, may push it into the stomach. The Röntgen rays are useful in some cases.

Treatment.—If there is dangerous dyspnœa, laryngotomy or tracheotomy must be at once performed. The foreign body may be removed by forceps, probang, or coin-catcher according to its nature, shape, and position. Impacted coins have their surfaces antero-posteriorly—a point to be remembered in using the coin-catcher. If all attempts at extraction fail, œsophagotomy must be performed and the body extracted. When a foreign body is impacted low down, a cautious attempt may be made to push it into the stomach with a bougie; but this is always dangerous, and especially so when the foreign body is rough and jagged, and it may result in laceration of the tube. Should this proceeding fail or be unadvisable, the stomach must be opened and an attempt be made to withdraw the body through the cardiac orifice.

bones, vertebral sequestra; *pieces of meat* and vegetable, fruits and kernels, potato, pieces of wood and grain, lung, egg, hair, cork, comb, sponge, spindle, dominoes, violin pegs, comfits, cake, flute-stopper, *teeth and dental plates*, masses of rag, feathers, tobacco. *Pins*, *needles*, pens, *coins*, *flat and round bodies* (child's saucer, medals), toys, palate obturator, knives, scissors, compass, razor-blades, sword-blades, forks, spoons, rings, *buttons*, buckles, keys, pebbles, glass-vials, pieces of stone or brick, thermometers, bullets, bars, pieces of pots, eye-glasses, butcher's hone, iron file, brass chains, lead seals, tubes and pipes, diamonds, table-rollers, sucking-bottles, beads, sounds, plaster, padlocks, fish-hooks, barbed wire, meat-skewers, tin-tag from tobacco.

CHAPTER XV

Injuries of the Eye and their Effects[1]

By Donald Gunn, F.R.C.S. Eng.

Assistant-Surgeon to the Royal Westminster Ophthalmic Hospital; Ophthalmic Surgeon to the Hospital for Sick Children, Great Ormond Street, and to the Seamen's Hospital, Greenwich.

INJURIES TO THE ORBIT

The orbital walls may be involved by any extensive fracture of the base of the skull. If there is hæmorrhage into the orbital contents the blood finds its way forwards into the lids and under the ocular conjunctiva, or accumulating behind it, may push the eye bodily forwards. This condition differs from the ordinary "black eye" in that the blood comes from behind forwards and is, therefore, less marked close to the corneal margin and takes much longer to appear. If the fracture traverses the apex of the orbit any of the structures entering or leaving the cavity may be damaged, the nerves suffering most commonly. A fracture of the base may involve the intracranial portion of the same nerves. In either case the injury causes loss of function evidenced in the case of motor nerves by the onset of squint and in the case of the optic nerve by sudden and complete blindness without any immediate ophthalmoscopic change, but followed in about three weeks by optic atrophy.

If the fracture involves the inner orbital wall and lacerates the nasal mucous membrane, a communication is established between

[1] For diseases arising independently of injury, the reader is referred to the standard works on Ophthalmic Medicine and Surgery.

the orbit and the air cells of the nose and consequently emphysema of the lids or ocular conjunctiva is likely to occur when the patient blows his nose, the air being thereby forced into the cellular tissue. The characteristic crepitation on pressure will be present.

Fractures limited to some part of the orbital walls are usually the result of heavy blows about the eye or of a penetrating wound of the orbit such as may be caused by a thrust with a foil or an umbrella. Penetrating wounds are particularly dangerous since the thrust is usually delivered somewhat upwards and hence the orbital roof may be perforated and the frontal lobes of the brain lacerated by the weapon or displaced spiculæ of bone, and death from septic meningitis is of common occurrence. Blows on the external angular process of the frontal bone often cause fracture extending through the optic foramen and if the optic nerve is damaged blindness follows immediately.

A deep punctured wound of the orbit, generally inflicted by a stab with a knife, may divide the optic nerve and cause blindness; a penetrating foreign body may break off and remain in the orbit for an indefinite period without its presence being suspected. Pieces of wood, slate-pencils, iron nails, etc., are occasionally found on opening an orbital abscess, especially in the case of children from whom no accurate history of previous injury can be obtained. After severe blows upon the orbital rim the eyes sometimes become sunken (*traumatic exophthalmos*). This is probably due to wasting of the orbital fat consequent on hæmorrhage into its substance and subsequent shrinking of the clot; more rarely some of the orbital fat projects into the antrum which has been opened by fracture of the floor of the orbit, and cases have been recorded in which even the eye itself has dropped into the antrum.

WOUNDS OF THE LIDS

Wounds of the eyelids heal very readily but as even the slightest irregularity at the margin of a lid causes a most noticeable deformity it is of great importance to secure exact apposition of the parts. The best material for the sutures is horse-hair, which should be passed not quite through the entire thickness of the lid. In suturing a divided lid the best guide to position is the line formed by the eye-lashes, and it is well to begin by putting a fine stitch on each side of the lashes. If the eye-lashes then form an unbroken line, the other skin stitches must be inserted, and if there is much

tendency for the wound to gape, the finest hare-lip pin may be used with advantage.

INJURIES OF THE CONJUNCTIVA

Wounds of the ocular conjunctiva heal readily enough as there is practically no displacement; sutures are seldom necessary. A careful examination of the eye itself should always be made to guard against the possibility of overlooking a perforation of the globe or some serious injury to its deeper structures from contusion. The two most important points to note are the tension of the eyeball and the state of the vision, this should always be done before the eye is bandaged in order that a prognosis may be given with some degree of confidence.

INJURIES OF THE CORNEA

Examination of the cornea.—A few drops of a 2 per cent solution of cocaine will allay the spasm of the lids and enable the surgeon to examine the eye by a strong light which should be concentrated upon the cornea with a convex lens. Much help may be gained from the use of a drop of a solution composed of 5 grs. of fluorescein and 10 grs. of bicarbonate of soda to the oz. of water. Fluorescein, which is one of the coloured bodies derived from coal-tar, possesses the peculiar property of rapidly staining a bright green colour any portion of the cornea from which epithelium has been removed without having any effect upon a cornea the epithelium of which is entire; an inconspicuous scratch, therefore, on the application of fluorescein solution becomes at once evident as a bright green line.

Injuries of the cornea may vary from abrasions of the surface to complete penetration, and the amount of pain they cause must not be regarded as an index to their gravity. Abrasions in which the epithelium is stripped off the surface of the cornea are often caused by a slight injury, such as a scratch from a baby's finger-nail. When recent the denuded spot is quite transparent and may be easily overlooked; as the fine nerve fibres are exposed by the removal of the corneal epithelium the pain and dread of light are always severe and movements of the lid over the denuded area cause acute suffering.

Perforating wounds of the cornea are almost always complicated by injury to some of the deeper structures, such as the iris

and lens, or by the retention of the penetrating body within the eye. They will be considered under Penetrating Wounds of the Eyeball.

Treatment of injuries of the cornea.—Except for the removal of foreign bodies cocaine should not be employed, since the relief it affords is quite temporary and the congestion following its use increases rather than lessens the patient's discomfort. Even the most trivial injuries of the cornea deserve careful attention and treatment (1) on account of the acute pain and discomfort they cause, (2) because, if centrally placed, the resulting opacity is likely to permanently lower the vision of that eye, and (3) because the smallest wound may be the starting-point of septic infection and ulceration.

The movement of the lids over an abraded cornea can best be controlled by a pad of wool and a bandage. If before applying this some simple ointment be put into the conjunctival sac the friction from the movements of the eye itself (which of course cannot be controlled) is reduced to a minimum. The eye should remain bandaged for some days until the epithelium has been renewed and all dread of light has passed away. In some cases of abrasion the pupil of the injured eye is, in consequence of the increased vascularity of the iris, obviously smaller than that of its fellow (*congestion myosis*); in such cases a drop of atropine should be put into the eye. In using atropine for this or any other reason the patient must be warned that the use of it will make the sight of that eye dim for some days.

INJURIES OF THE CORNEA BY ESCHAROTICS

Short of perforation no injuries are more destructive than burns with quicklime, molten metal, or strong acids; the resulting corneal opacity is always very dense and there is often union of the lids to the eye-ball (*symblepharon*). The gravity of these lesions is often much greater than would appear at first sight, for the resulting corneal leucoma is generally very dense and the cicatricial contraction of the conjunctival sac may go on for many weeks after the original ulcer has healed and may consequently produce defects and deformities quite out of proportion to the apparent seriousness of the burn when seen as a recent injury. A guarded prognosis must therefore be given when the injury involves more than a very small fraction of the conjunctival surface, for at the best symblepharon is likely to result.

A splash of molten metal is sometimes gripped by the instantaneous

closure of the lids and on cooling forms a more or less complete mould of the lower cul-de-sac. The caustic action of quicklime or burning phosphorus is prolonged and extremely severe, more so even than that of molten metal which rapidly cools and does no further damage.

Treatment.—The immediate treatment of an eye when injured by an escharotic should be the removal of all solid particles and thorough washing out of the conjunctival sac; the use of cocaine is advisable as a preliminary. By the time the case comes under treatment the profuse secretion of tears has, as a rule, been sufficient to remove the irritant except in the case of solid matter; otherwise a weak neutralising solution of acid or alkali, as the case may demand, should be used. The after-treatment of the case should consist in frequent irrigation to wash away sloughs with the use of some simple ointment, such as boracic acid, to lessen the friction of the raw surfaces upon one another. Pain which is usually severe at night should be controlled by opium. No attempt should be made to break down adhesions as they form, for this only delays healing without effecting its purpose. When cicatrisation is complete and all morbid action has disappeared and the full extent of the symblepharon is evident a good deal may be done by operation to obviate the traction of the lids upon the globe by which the movements of the eye are sometimes hampered and rendered painful. Such operations consist in dividing bands and filling in the resulting gaps with parts of the healthy conjunctiva, or with grafts taken from the mucous membrane from the inner surface of the lips.

FOREIGN BODIES BENEATH THE LIDS

One of the commonest injuries to the cornea is the impaction in it of particles of a minute foreign body, often a fragment of a cinder from a railway engine; tool grinders, fitters, and other workers in metal are especially liable to such injuries. The symptoms produced are similar to those met with in abrasions. If no foreign body can be seen in the cornea the precaution of everting the upper lid should never be omitted, as very frequently the offending particle adheres to its under surface near the free margin, and causes great pain by scraping the surface of the cornea on each movement of the lid or eye.

Removal of a foreign body from the eye.—This is most conveniently done while standing behind the patient, who should be

seated in a low chair with his head thrown back and resting against the surgeon. The fault common to all spuds made for the removal of foreign bodies is that they are too large and blunt, the result being that much unnecessary damage is done by the surgeon in his efforts to scrape the particle from the spot where it is embedded. The instrument used for this purpose cannot be too fine (a needle, such as is used for the discission of cataracts, is as good as any) and the foreign body should be lifted from its bed by inserting the point of the instrument under its edge; in this way it can be removed whole at the first attempt and no further damage is inflicted by prolonged and injudicious scraping. The surgeon's left hand is best employed in holding a lens so as to concentrate the light upon the cornea, for after the use of cocaine the patient, if told to keep both eyes open, will have no difficulty in remaining steady and looking in any direction required.

HYPOPYON ULCER

Sometimes a small abrasion or wound of the cornea instead of healing takes on an unhealthy action and spreads by progressive infiltration and necrosis of its margin. This is due to infection of the wound by some pyogenic organism. If this misfortune occurs the eye becomes very painful, especially at night, iritis sets in, and pus appears in the lower part of the anterior chamber (*hypopyon*).

Although the liability to small corneal injuries is common to many callings and although any injury, however trifling, is a possible starting-point for this spreading ulceration it is seldom seen in young workmen earning good wages—that is, in men with sound tissues who are well fed—nearly all the cases occurring in ill-nourished men past the prime of life. Pauper stone-breakers and old agricultural labourers, especially those engaged in harvesting and hedge-cutting, furnish the majority of such cases, and it is the possibility of the occurrence of this infection, especially in such people, that should teach us to treat all corneal injuries with care and watchfulness.

The immediate source of infection is often the presence of muco-pus in the lacrimal sac, which can always be detected by making pressure with the finger-tip over the position of the sac, when, if any collection be present, the fluid will regurgitate through the puncta lachrymalia into the conjunctival sac.

One characteristic form of this spreading ulcer advances at some portion of its margin while remaining stationary or healing elsewhere. The spreading edge is always seen as a curved yellow

crescentic line which creeps across the cornea first in one direction, then in another (*serpiginous ulcer*). Occasionally an offshoot from this advancing edge burrows beneath the surface between the layers of the cornea and forms a localised purulent deposit (*corneal abscess*). When a hypopyon has once formed the collection in the anterior chamber tends to increase as long as the corneal ulceration progresses, till the anterior chamber may be nearly full of a thick tenacious pus. Iritis is always present, and pain, radiating over that side of the head, is usually severe. If untreated, especially in patients of feeble constitution, the ulcer tends to spread in extent and depth till the cornea gives way and the aqueous escapes, generally washing the pus away with it. This is often the starting-point of an improvement, in which case the pain ceases and the ulcer heals from the time of perforation but as the iris remains entangled in the perforation and the cornea is extensively scarred the eye is seldom of any use.

Treatment.—Local treatment must be directed to arresting the spread of the ulcer and general treatment to the alleviation of pain and improvement of the patient's condition.

The use of atropine with fomentations frequently renewed often suffices in the earlier stages to start the healing of the ulcer and the absorption of the hypopyon, but if under this treatment it is evident that the ulcer continues to spread and the hypopyon to increase in size the ulcer must be checked by destruction of its advancing edge. This can be done most effectually by destroying the infiltrated margin with the galvano- or thermo-cautery or by scraping with a small sharp spoon. Local anæsthesia is sufficient if the use of cocaine solution is followed by the application of a little solid cocaine to the ulcer. In the worst cases the natural course of events may be anticipated by making an incision through the cornea and letting out the hyopyon. If perforation of the cornea occurs spontaneously and the iris is prolapsed the prolapsed portion should be drawn out clear of the perforation and cut off with scissors, as in the case of a penetrating wound. Whatever local treatment is adopted the patient is likely to benefit by an improved diet with tonics and stimulants.

Injuries of the Globe

CONTUSIONS

The eye is so well sheltered by the nose, brow, and cheek, that it seldom receives the full force of a blow except from a missile

small enough to escape these bony prominences, but when struck by the cork from a soda-water bottle, a racket ball, or a similar object, serious damage may be caused by hæmorrhage into the media or by rupture and displacement of the deeper structures.

Hæmorrhage within the eye.—Hæmorrhage may occur into various structures.

Hæmorrhage into the aqueous comes from the vessels of the iris or ciliary processes and the blood settles in the lower part of the anterior chamber where it is seen as a dark red mass having a horizontal upper border (*hyphæma*).

Hæmorrhage into the vitreous may take place from the retina, choroid, or ciliary processes. When in small quantities it can be seen with the ophthalmoscope as dark floating webs but when profuse it may so discolour the vitreous as to entirely abolish the normal fundus reflex. Under these circumstances the pupil, when examined with the mirror, appears black, but focal light—that is, the light of a lamp concentrated on the pupil with a lens—often reveals the blood as a red mass behind the level of the iris. The patient sometimes describes his loss of sight as having begun with a red cloud.

Hæmorrhage into the retina is generally present when there is hæmorrhage into the vitreous but may occur independently of it, the hæmorrhages are often multiple and are seldom of large size. Blood sometimes escapes forwards from the retina without breaking into the vitreous; these *subhyaloid hæmorrhages* are often of large size, and assume a characteristic semilunar shape.

Hæmorrhage from the choroid, especially when originating from the deeper choroidal vessels, is often profuse, the blood being poured out behind the choroid which it strips off the sclerotic. This copious form of choroidal hæmorrhage may occur during an operation for cataract or glaucoma, especially if the vessels of the eye are not healthy; in such cases it is due to the sudden lowering of the intraocular tension by the incision in the cornea, and may be sufficiently copious to force the vitreous out of the wound.

Detachment of the iris.—A blow upon the eye may detach the iris at its periphery leaving a spindle-shaped gap (*coredialysis*), or the iris may fissure radially (sometimes in many places) at its pupillary margin.

Muscular paralysis.—As the result of contusion of the globe the iris may be paralysed, the pupil is consequently dilated though generally not circular, and is inactive to light. This condition of *mydriasis* may pass off in a few days or remain permanently.

Partial or complete paralysis of the ciliary muscle (*cycloplegia*) may also be present and is evidenced by the patient's inability to see near objects distinctly; he will therefore be unable to read printed matter though his sight for distant objects remains much as before the injury. Akin to these two paralyses is the drooping of the upper lip (*ptosis*) occasionally caused by blows about the eye.

Dislocation of the lens.—The lens is normally held in position by the fibres of the suspensory ligament which radiate from its margin to the ciliary processes. When this ligament is torn by a blow on the eye the lens, losing its support, is more or less completely displaced; the amount of displacement varies from slight tilting to a complete dislocation, forwards into the anterior chamber, or backwards into the vitreous humour. In the slighter cases, in which the displacement is not sufficient for the edge of the lens to appear within the pupil, the diagnosis is often difficult. A tilted lens pushes the iris forward at one part of the circle while at the opposite point the iris, losing the support of the lens, becomes tremulous upon quick movement of the eye; when the lens is completely dislocated backwards this tremulousness affects the whole iris, and is very noticeable. A dislocated lens may remain transparent for many years but more commonly it slowly becomes opaque and shrinks.

The symptoms of a dislocated lens vary with the direction and completeness of its displacement. When it lies in the anterior chamber acute glaucoma usually results. When dislocated backwards the lens sinks on to the lower ciliary processes and acting there as a foreign body causes changes in nutrition which, as a rule, ultimately lead to detachment of the retina and loss of sight; for this reason the old operation of "couching" (which consists in depressing a cataractous lens backwards into the vitreous) seldom gave a permanently good result. A blow on the eye may cause a cataract from rupture of the capsule without displacement of the lens; the rupture sometimes occurs in the posterior capsule (*concussion cataract*).

Detachment of the retina.—When following immediately on a blow, detachment of the retina is due to hæmorrhage between it and the choroid; more frequently it is a late result caused by cyclitis and fibrous changes in the vitreous, which consequently shrinks and carries the retina with it away from the choroid, the space between the two being filled by a serous fluid. In an eye predisposed to retinal detachment, such as a myopic eye, a blow anywhere about the head may be the starting-point of this con-

dition independently of any inflammatory changes which may be excited.

Rupture of the choroid.—Linear splits in the choroid occur about the posterior parts of the eye and are at first concealed by blood and by haziness of the overlying retina. Later they are recognised ophthalmoscopically as tapering white lines (really rifts in the choroid) which are usually curved with a concavity towards the optic disc; sometimes they are branched. The unaltered retinal vessels are seen passing across these lines. If the rupture is near the "yellow spot" sight is always much impaired.

Diminished tension.—As the result of a blow, with no obvious serious damage, the tension of an eye may sometimes be considerably lowered. This is due to rupture of the ligamentum pectinatum at the angle of the anterior chamber, consequently the aqueous escapes more readily through the spaces of Fontana.

The prognosis of contusions of the globe.—In all cases of contusion of the eye a guarded prognosis must be given if there is any defect of sight, although, if this is due to hæmorrhage into the media, partial or complete recovery is possible. Blood in the aqueous humour quickly settles to the lower part of the anterior chamber and unless it is in large quantity interferes but little with sight. Moreover, it is as a rule rapidly and completely absorbed. Blood in the vitreous humour is absorbed much more slowly and is likely to leave permanent opacity. In children absorption is more rapid, and a vitreous that has been quite impervious to light sometimes clears in a surprising manner. Blood in the vitreous may conceal a central injury to the retina or choroid; the defect of sight may then be only partially accounted for by the state of the media and we must wait until a complete examination of the fundus can be made before giving a definite prognosis.

Treatment of contusions of the globe.—Complete rest should be maintained by the use of atropine and a light pad and bandage till recovery is as far as possible complete. If there is any pain, it may be relieved by the application of leeches to the temple.[1]

[1] Although in general surgical practice the use of leeches has almost been abandoned, they remain in ophthalmic practice the best means of relieving pain. This is especially true of the pain due to iritis. A few words upon the method of employing leeches will, therefore, not be out of place. When the real leech cannot be obtained, the artificial leech of Heurteloup makes a fairly efficient substitute, or, failing this, some other modification of "wet cupping" may be employed. A useful number of leeches to apply to an adult is two or three; to a child, one is sufficient. The most

In recent cases, where there is reason to suspect hæmorrhage, cold should be continuously applied to the eye by means of iced water, evaporating lotions, or an ice poultice. An ice poultice is made as follows :—

Take two tablespoonfuls of bran and grate over it with a bread grater a piece of ice as large as a walnut, sprinkle this with a salt-spoonful of fine salt, mix the whole together, and enclose in a piece of gutta-percha tissue which should be sealed with chloroform. Some care is needed in the use of this mixture of ice and salt, as a very low temperature is produced. The bran acts mechanically in slowing and modifying the freezing mixture, much as the earth modifies the action of the nitro-glycerine when they are mixed to form dynamite.

The removal of a dislocated lens is always a matter of great difficulty and in the majority of cases should not be attempted so long as the eye remains quiet. Treatment of detached retina is extremely unsatisfactory. The plan usually adopted is that of keeping the patient at rest in bed for some weeks with his eyes bandaged ; the improvement gained is, as a rule, quite transient.

convenient spot at whieh to apply the leech is, for several reasons, the temple of the affeeted side, about one inch from the "corner of the eye," though patients sometimes say that they get more relief when the blood is drawn above or below the eye. In any case, select a spot over a bone, so that if neeessary effectual pressure can be employed to stop the bleeding. In applying more than one leech, do so one at a time ; they ean then all be made to bite within a very small area.

The patient lying on his side, with his head upon a low pillow, the temple is to be carefully washed with soap and warm water, and gently rubbed with a soft towel till the skin flushes slightly. The leech is then wrapped in a piece of damp soft linen, with its head (that is, the smaller end) exposed, and held gently at the selected spot till it bites ; when it has taken a firm hold the wrapping is removed, and it is left to suck its fill. It should not be pulled off, but allowed to drop off when satisfied. As soon as the first leeeh has seeured a hold, the seeond may be applied close to it in the same way. If a leeeh be simply placed upon the patient's temple and allowed to move about, it may travel some distanee before it elects to bite ; and even if eonfined in the usual way beneath an inverted pill-box, its sphere of action cannot be limited with any aecuraey.

A leech, when slow to bite, may sometimes be induced to do so by smearing a little milk upon the skin ; but a more certain method is to prick the skin with a needle. The drop of blood then forms a bait that, as a rule, is taken with avidity.

When the leech has dropped off, bleeding may, if necessary, be further encouraged by the application of a warm sponge.

To stop the bleeding, press a scrap of cotton wool firmly on the bite for a few minutes, and, on removing that, quickly replace it by another bit of wool steeped in collodion. If necessary, a pressure-pad and bandage can be applied. When the bleeding is diffieult to stop, an effectual plan is to pinch up the skin so as to open the bite, the latter can then be plugged with a shred of amadou or cotton wool pushed into it with the blunt end of a fine needle.

The pain of iritis is often relieved before the leeehes have finished sucking.

RUPTURE OF THE GLOBE

Rupture of the globe is usually the result of a heavy blow with a closed fist upon the eye of a patient past middle life. Almost constantly it is the sclerotic which gives way, and this at its thinnest part—that is, in front of the insertion of the recti muscles. The line of rupture is usually about 4 millimetres behind and parallel with the upper part of the sclero-corneal junction. The retina and choroid also give way and there is free hæmorrhage into the interior of the globe, forcing out its contents through the rent. The vitreous is lost, and the lens, or even the whole iris, may escape through the opening; the eye is consequently collapsed and is usually sightless. If, as sometimes happens, the conjunctiva remains unbroken, the interior of the eye is not in communication with the air and the condition is not so hopeless since suppuration is not so likely to occur. Sometimes, in a sub-conjunctival rupture of this kind, the lens escapes through the gap in the sclerotic and forms a prominence outside the globe but still covered by conjunctiva; if it be left in this position, it may undergo absorption without causing further trouble. Ruptured eyes, at any rate when much collapsed, are best excised at once.

PENETRATING WOUNDS OF THE GLOBE

Penetrating wounds of the eye are those by which the cavity of the globe is opened. The simplest form of penetrating wound is that in which the cornea alone is perforated by some clean instrument and in which none of the contents of the globe escape except the aqueous. Such injuries are rare.

Complications.—All penetrating wounds are dangerous to sight but their gravity in some measure depends upon (1) the size of the wound; (2) its position; (3) whether or not deeper structures, such as the iris or lens, are implicated; (4) the possible introduction of septic material; and (5) whether a foreign body has been retained.

The size of the wound.—If the opening be large the contents of the globe escape at once being often forced out by hæmorrhage into its interior and the eye is completely disorganised, but if the wound be small the prognosis and treatment will be influenced by other conditions.

The position of the wound.—Behind the corneal margin is a zone about a quarter of an inch in width, representing the position of the ciliary body. This zone is known as the "dangerous area,"

experience having shown that wounds within it—that is, wounds of the ciliary body—are more likely to cause sympathetic ophthalmia than are those either in front of or behind this area.

Implication of the deeper structures.—When the perforation is in the cornea the iris is usually wounded and as this is in contact with the front of the lens a wound of the former almost of necessity involves the latter. Either of these complications adds materially to the gravity of the injury. The aqueous in suddenly escaping through a corneal opening carries the iris, even if uninjured, into the wound, forming an *anterior synechia*. This incarceration of the iris delays the healing of the wound and the presence of the anterior synechia increases the risk of the eye giving further trouble. The lens when wounded rapidly becomes opaque (*traumatic cataract*). This opacity is due to the opening of the lens capsule and the exposure of the lens fibres to the action of the aqueous humour. The aqueous contains a trace of chloride of sodium and the lens fibres when exposed to the action of such a saline solution swell up, become opaque, and are ultimately dissolved. Upon this fact depends the possibility of treating idiopathic cataract in young subjects by the method commonly adopted; the operation consists in opening the lens capsule with a fine needle and allowing the aqueous to gain admission to the substance of the lens which then becomes dissolved and absorbed.

When the perforation is in the sclerotic the choroid and retina are necessarily wounded and unless the opening be very small some of the vitreous will escape.

The introduction of septic material.—The introduction of pyogenic organisms within the eye-ball at the time of or subsequent to perforation is likely to be followed by a rapid reproduction and extension of such organisms, especially in the posterior parts of the globe. The ciliary body, which is the secretory and nutritive centre of the eye, circulates the materies morbi to the tissues it normally nourishes, and the vitreous, being a highly albuminous substance, forms a very favourable culture medium for micro-organisms. The changes therefore tend to become general and lead to suppuration throughout the globe (*panophthalmitis*), or if the organisms possess only slight virulence, to a slow shrinkage and ultimate blindness of the eye.

The presence of a foreign body within the globe (see p. 311).

Treatment of penetrating wounds of the globe.—If a wound in the sclerotic is not so extensive as to necessitate excision of the eye and there is no suspicion that the eye contains a foreign

body the immediate treatment consists in cleansing the wound and conjunctival sac with a 1 in 3000 solution of perchloride of mercury, followed by the instillation of atropine and the application of a cotton wool pad and a bandage. Any protrusion of vitreous should be cut close off with scissors and the conjunctiva should be stitched over the opening with a fine silk suture. The gap in the sclerotic will, if all goes well, be slowly filled in by fibrous tissue. If the wound be in the cornea and prolapse of the iris has occurred, the protruding portion, if very small, may sometimes be pushed back into the anterior chamber with a fine probe; more often this is impossible, and it must be removed. To do this, the prolapse is grasped with iris forceps and drawn out till it is on the stretch, it is then cut off with scissors close to the corneal surface; if this is properly done the cut edges will retract within the anterior chamber leaving a gap in the iris opposite the corneal wound.

If the lens has been wounded the case must be carefully watched from day to day, for the rapidity with which a wounded lens swells depends upon the size of the opening in its capsule. With a large capsular opening the lens may swell more rapidly than it can be absorbed, the tension of the eye then rises and the condition of glaucoma supervenes; should this occur there is great pain, often accompanied by vomiting as the tension rises. Operative interference then becomes a necessity, and prompt relief must be afforded by making an incision through the cornea away from its centre and removing through it as much of the softened lens as can be easily got away with a curette.

In cases of penetrating wounds of the eye, a question that frequently has to be faced is whether the eye should be preserved or excised, and no decision in the whole of ophthalmic surgery carries with it a graver responsibility than this. If we were concerned only with the fate of the wounded eye, the treatment would always resolve itself into doing all we possibly could to preserve an eye that had even the poorest vision. But in the face of the knowledge that certain injuries, though apparently trivial, frequently cause a destructive inflammation of the other eye, our verdict must be based not so much upon the amount of sight the injured eye retains as upon its probable life-history. The practice among ophthalmic surgeons in this country has, in cases of doubt, always been to regard the removal of an injured eye as preferable to exposing the patient to the risk of losing the other and this probably remains our safest course, at least until we have learnt more about the prevention and cure of sympathetic ophthalmia.

FOREIGN BODIES WITHIN THE EYE

The presence of a foreign body within the eye has an important bearing upon the question of performing excision in order to avert the risks of sympathetic inflammation. Eyes long blind from injury after keeping quiet for, perhaps, many years tend, on the receipt of some fresh though trifling injury, to become painful and to develop all their latent irritability; this is especially likely to occur if an eye contains a foreign body, or is the seat of osseous degeneration.

The retention of a foreign body within the globe is most likely to result when the foreign body is small and was moving rapidly at the time it caused the accident, as in the case of a shot from a gun or a splinter of steel. Such a body tends to sink slowly in the vitreous and to come to rest on the ciliary processes below. As a result of the irritation caused by its presence in this situation a slow form of plastic cyclitis is set up, the vitreous becomes infiltrated and shrunken, the retina detached, the lens opaque, and the eye blind. Such an eye is liable to recurring attacks of pain and inflammation and may at any time set up sympathetic inflammation in the other. In forming an opinion of the possibility of a foreign body being in an eye the greatest care must be taken to carefully sift all the evidence bearing upon this point and in making an examination of the eye itself. The patient seldom has any suspicion that his eye contains the splinter of metal which struck it, but his account of the accident will enable the surgeon to form an opinion as to the probable size, nature, and velocity of the penetrating body. An examination of the tools with which the patient was working may show a recent flaw where a splinter has flown off the face of a hammer or the head of a punch. A methodical examination of the eye should be made as soon as possible, for if it be delayed and the lens be wounded, the latter will soon become too opaque to allow of a view of the deeper parts being obtained. If the aqueous has escaped time should be allowed for its re-secretion and if the eye be bandaged, this will probably be only a matter of a few hours. Another possible obstacle to immediate examination with the ophthalmoscope is the presence of blood in the vitreous. The acuteness of vision and the tension should always be noticed, each being compared with that of the sound eye.

To examine an eye supposed to contain a foreign body.—If the anterior chamber is empty, it is evident that the cornea has been perforated. If some time has elapsed since the injury and the aqueous has been re-secreted, an adhesion of

the iris to the corneal scar will be equally good evidence on this point.

Before dilating the pupil with atropine examine the iris carefully for a wound and if one is present compare its position with that in the cornea, the relative positions of the two will give the direction taken by the penetrating body. Blood in the anterior chamber (*hyphæma*) may conceal a wound of the iris but at the same time is strong evidence of its existence.

After dilating the pupil examine the lens by transmitted and by focal light. A recent and small track through its substance may be only indicated by a faint line.

Examination of the vitreous with the ophthalmoscope may show blood to be present; it appears as dark red blotches or streaks.

White glistening rifts are sometimes present in the vitreous after the passage of a foreign body through it, and may easily be mistaken for fragments of steel or glass. These rifts are similar to the air-cracks in a piece of ice and may be observed to diminish day by day.

Lastly, the fundus of the eye must be searched bit by bit by the direct method of examination with the view of detecting the foreign body or any evidence of its whereabouts.

A patch of retinal hæmorrhage may conceal a foreign body which has traversed the globe and become embedded in the sclerotic in the neighbourhood of the posterior pole, or it may mark the spot where the foreign body has wounded the retina and choroid and then fallen back again into the vitreous; or lastly, where the body has penetrated all the coats a second time and has passed out of the globe into the orbital tissues. Of these three possible conditions it is evident that the one in which the foreign body has passed out of the eye will be, relatively, the most favourable. Failing to find the body elsewhere, search should be made in the vitreous as far as possible downwards, since it will gravitate in this direction. The chemical nature of any substance retained in the eye will, in some measure, determine the amount of irritation it causes. Metals, by reason of the changes they undergo, are less likely to be tolerated than are chemically inert bodies such as glass or stone. Metals, however, vary in the readiness with which they form salts, and the salts differ in their properties and consequently in the amount of irritation they are likely to produce. For this reason an eye containing a fragment of copper has a worse prospect than one containing a piece of iron of the same size. Before the introduction of breech-loading guns many eyes were lost from injuries from the copper percussion caps then in use.

When a fragment of metal remains entangled in the cornea or sclerotic at the point of penetration much difficulty may be experienced in removing it. When embedded in or adherent to the iris it is generally best to do an iridictomy and remove the foreign body along with the damaged portion of the iris. A foreign body in the lens causes less irritation than it does in other parts of the eye, and the lens, when it has become opaque, can sometimes be removed without disturbing the foreign body. More frequently a foreign body comes to rest in some part of the vitreous, and although, since the electro-magnet has been used for this purpose, the removal of particles of iron and steel can be effected with more certainty and with less instrumentation than formerly, yet wounds of this class are still among the most dangerous that occur in ophthalmic practice; for even if the foreign body be successfully removed the case still remains one of penetrating wound and the damaged eye is still liable to suppurative inflammation or to set up sympathetic ophthalmia. Recent experience has, moreover, shown that an eye, from the vitreous of which a foreign body has been removed, does not, even under the most favourable conditions, quiet down or recover as readily as might be expected, and a considerable proportion of such eyes have ultimately to be excised.

The Röntgen rays have recently been employed for the detection of metallic foreign bodies in the eye, and will prove of great service especially if any doubt exists as to the fact. The cases in which this method of investigation seems most likely to be of use are those where the presence of blood in the vitreous makes ophthalmoscopic examination impossible.

PANOPHTHALMITIS

After infection of a penetrating wound by pyogenic organisms, the suppurative process usually spreads with great rapidity throughout the globe. Some portion of the track of the wound first shows as a yellowish line of infiltration, and the cornea, if the wound involve it, may necrose. Iritis is always present and the whole uveal track suffers. Hypopyon appears, and in acute cases the eye is filled with pus and hopelessly lost in one or two days, during which the patient usually suffers very severe pain. If there is an open wound the pus will drain away from it, otherwise the sclerotic may, to the patient's great relief, give way, the eye subsequently shrinking till it is a mere button.

This acute form of suppuration may follow any penetrating

wound of the eye, including operation wounds, but it is most common as a result of perforation with some obviously foul instrument such as a steel dinner-fork, an injury by no means uncommon among children who often use a fork to unpick knotted bootlaces. Penetration of the eye by a chip of metal, which is or has recently been heated and consequently possibly sterilised, will be less likely to lead to this infective suppuration, though the eye may be lost from slow changes following on the retention of such a chip. Any penetrating wound, surgical or accidental, must be regarded as the possible seat of infection, and in all operations care is necessary to ensure the asepticity of instruments, particularly of those which are to be introduced into the interior of the eye. One possible source of danger is the presence of pus in the lacrimal sac, and in all cases it should be a matter of routine before operating to ascertain by pressure on the sac that it does not contain muco-pus; should this be present, the condition must be rectified by treatment before the operation is undertaken.

Treatment.—Panophthalmitis when once established cannot be controlled and the eye must be excised. The removal of such an eye during the stage of acute suppuration is, however, sometimes followed by septic meningitis from escape of the contents of the eye into the orbital tissues at the time of operation. It is better, therefore, to defer excision till after the acute symptoms have subsided. In the meantime, to relieve the pain, which is intense when no opening in the eye exists, it is necessary to give exit to the pus; this can be done by passing a knife into the interior of the globe through the cornea or the anterior part of the sclerotic.

SYMPATHETIC OPHTHALMIA

The perforation of one eye by a wound or by ulceration is sometimes followed by a destructive form of inflammation in the other; that primarily affected is spoken of as the exciting eye, that secondarily affected as the sympathising eye. This disease is essentially an inflammation of the uveal tract centring on the iris and ciliary body, and though insidious in onset and often slow in progress, it tends when once established to go on in spite of all treatment and to cause severe damage to or destruction of sight. Sympathetic ophthalmia follows most frequently on wounds of the ciliary zone, or those in which the iris has been involved, but probably never occurs except when perforation from one cause or another has taken place in the exciting eye. The interval between

the perforation of an eye and the onset of sympathetic inflammation may vary within wide limits, for though it is seldom less than two or three weeks it may extend over many years of apparent immunity, but inflammation of the exciting eye, more or less pronounced, always precedes the appearance of sympathetic inflammation. Many eyes which have been long blind are liable to inflame from time to time; this is especially the case if they contain a foreign body or if osseous degeneration has taken place in the choroid; the possession of such an eye is, therefore, always a possible source of danger.

The pathogenesis of sympathetic ophthalmia cannot yet be regarded as definitely settled, but of the various theories which have from time to time been brought forward, the one most consistent with observed facts and most in harmony with modern knowledge is that which assumes the cause to be some specific substance of the nature of a germ or a germ-product (probably the former) which, having found an entrance into the eye through a perforation, travels along the lymph channels of the optic nerves to the sound eye and reproduces in it an inflammation of the same structures as were primarily affected—that is, the iris and ciliary body. Wounds which are wholly or partly within the ciliary zone—that is, within a zone a quarter of an inch in width situated immediately behind the corneal margin—are especially liable to cause mischief in the other eye; this is particularly so if they are lacerated or if vitreous has escaped, for such wounds are necessarily slow in healing. Eyes that contain a foreign body can seldom be preserved with safety. Operations on the eye, especially if the iris be entangled in the incision, are sometimes followed by sympathetic inflammation in the other eye.

Sympathetic inflammation is sometimes preceded by a condition of functional disturbance known as sympathetic irritation, in which the sympathising eye becomes the seat of neuralgic pains, is intolerant of light, and tires rapidly on any attempt to read or do close work. This condition is not always present before the commencement of the more serious disorder, nor when present does it always run on to sympathetic inflammation, and unlike it is promptly cured by the excision of the injured eye.

In the early stages of sympathetic ophthalmia the changes in the sympathising eye may not be very obvious, but a careful examination will always prevent their being overlooked or mistaken for some slight form of conjunctivitis.

There is some turbidity of the aqueous, with the formation of

circular spots on the posterior surface of the cornea (*keratitis punctata*). The colour of the iris is altered and the reaction of the pupil to light is defective. There is deeply seated injection of the ciliary region, with tenderness on pressure. The vitreous is hazy from the presence of dust-like opacities. Neuro-retinitis is often present. Pain is seldom a marked symptom. These are the distinctive features of an early stage, and should the disease stop at this point recovery may follow and useful sight be preserved; but, as a rule, the iritis progresses in an intractable manner, the pupil becomes tied down by synechiæ and blocked with lymph, the iris bulged forwards, the anterior chamber shallow, and the vitreous infiltrated, its subsequent shrinkage leading to detachment of the retina.

The **treatment** of sympathetic ophthalmia is sufficiently unsatisfactory to emphasise the importance of its prevention. When once established, the course to be adopted with regard to the exciting eye will depend upon the amount of sight retained by it. If it is blind there can be no doubt as to the propriety of excision, but if the injured eye has fairly good sight it should not be excised, for there is a possibility that it will prove to be the better eye of the two by the time the inflammation has run its course.

In any case, removal of the exciting eye seldom has any marked effect on the disease when it is once established, and hence the necessity of removing a damaged eye before the onset of sympathetic ophthalmia (see p. 310).

The constitutional treatment generally consists in the administration of mercury, and though there is little evidence that it does good, yet its undoubted usefulness in many forms of iritis justifies its use; at any rate, it can do no harm if given in small doses.

Locally, atropine must be used frequently to prevent as far as possible the formation of synechiæ; moreover, by dilating the pupil it lessens its liability to become blocked with lymph. Pain may be relieved by leeching but is not generally severe. Both eyes should be bandaged; if this is properly done, there is no necessity to keep the patient in a dark room or in bed. Treatment must be persevered with so long as there is any evidence of inflammation and this is often a matter of many months. In the chronic cases blisters to the temples, which should be repeated at short intervals, will often lessen the irritability of the eyes.

Iridectomy should not be performed until all inflammatory symptoms have passed off and the eye has remained quiet for at least

a month. If it is done while the disease is still active the gap in the iris is at once filled in by plastic exudation and nothing is gained. The aim should be to remove a large part of the iris, but it is often impossible to do this owing to the extensive posterior synechiæ and the friability of the iris tissue.

EXCISION OF THE EYE-BALL

In excising an eye the aim should be (1) to remove the whole globe, and (2) to preserve every structure that will help to form an efficient stump for an artificial eye. As a rule these points present no difficulty, but in dealing with a collapsed eye much care is needed, on the one hand to ensure that no portion of the globe is left behind, and on the other to avoid removing any portion of the outside structures.

The instruments needed are few—a spring speculum, fixation forceps, tenotomy hook, and curved blunt-pointed scissors being all that are necessary. The surgeon, as in all operations on the eye, stands at the head of the couch. The three successive steps in the operation are division of the conjunctiva, of the muscles, and of the optic nerve, in that order.

The lids being held open by the speculum, the conjunctiva is picked up with the forceps and divided close to the margin of the cornea. Before attempting to divide the muscles the capsule of Tenon must be opened; this is done by cutting directly backwards keeping the scissors underneath the conjunctiva and close to the surface of the sclerotic; it does not matter at what point this is done, provided that the opening is made in an interval between two of the recti muscles, one side or other of the inferior rectus is perhaps the most convenient point. When the capsule has been opened, the strabismus hook is passed into the opening and swept gently over the smooth surface of the sclerotic till it is under the tendon of one or other rectus muscle, the tendon is then divided close to its insertion. Each rectus muscle is similarly treated in succession; when all are divided the hook can be swept completely round the equator of the globe. The optic nerve is now found by passing the scissors, with the blades closed and the concavity forwards, behind the eye-ball and feeling for the nerve as with a probe; when found the scissors are opened and the nerve divided. If, after the recti muscles have been cut, the speculum is opened widely and then pressed backwards the eye will slip forwards; this puts the optic nerve on the stretch and makes its detection and

division easier. Any remains of the oblique muscles are to be cut close to the globe as it is lifted away. Firm pressure with a pad and roller bandage should be applied for a few hours to control any hæmorrhage, though this is seldom troublesome except after the removal of blind glaucomatous eyes, and can always be arrested by carefully plugging the orbit and applying pressure with a bandage; irrigation of the orbit with hot water is also a useful plan.

The eye-ball after removal should show a perfectly clean surface, and the points of insertion of the muscles should be recognisable only as lines and not by tags of tendon.

CHAPTER XVI

Injuries of the Chest and Thoracic Viscera

Injuries of the chest owe their importance to possible concomitant damage of its contents, which are, however, naturally protected by the elasticity of the parietes. All injuries may be accompanied by fracture of the ribs.

Contusion and concussion of the chest may be very trivial or so severe as to cause death, although sometimes no fatal lesion is found by *post-mortem* examination. In such cases death has been attributed by various writers to syncope from concussion of the heart or stimulation of the inhibitory fibres of the vagus, to sympathetic paralysis with engorgement of the abdominal viscera and consequent cerebral and cardiac anæmia.

In slight cases there are no ill effects beyond bruising of the tissues and some muscular pain on respiration, but in severe contusions there is more or less shock, with feebleness and irregularity of the heart-beat, and shallow respiration.

Contusion and rupture of the lung, rupture of the heart, or of a dilated and weakened aorta, may result from simple concussion of the chest without other injury to the parietes.

The **treatment** consists in combating the shock, the exhibition of stimulants assuming the thoracic viscera to be uninjured, and the maintenance of complete rest. In simple bruising of the chest, pain on respiration may be alleviated by strapping the side and confining the arm in a sling, followed in a few days by gentle friction.

Rupture of the pectoralis major may result from violence to the chest, especially if the arms are raised above the head and the muscle stretched. Some years ago I had, at the Westminster Hospital, a case of very extensive rupture of the left pectoral with

copious extravasation of blood and profuse and widespread suppuration. The accident occurred while the patient—about forty years old—was plastering a ceiling, and was due to overreaching with the arms above the head. In slight cases a few fibres only are torn. Sub-pectoral abscess is a possible sequel of the mischief.

Treatment.—The arm must be confined to the side and the patient kept in bed on his back, an ice-bag being applied to the seat of injury. If sub-pectoral abscess forms, it should be carefully opened in the axillary line at the most dependent part. Massage and passive motion of the arm should be practised when healing has occurred.

FRACTURE OF THE RIBS

Causes and situation.—The ribs, especially in the young, are naturally protected from fracture by their great elasticity; the upper ones are further protected by their position, and the lower by their shortness and freedom of movement; fracture is consequently most common from the fourth to the eighth inclusive. The most usual cause is indirect violence, such as a blow upon a sternum, or a severe squeeze of the chest in its antero-posterior diameter, the ribs giving way near their angles.

By direct violence the ribs are mostly broken at the anterior third. In rare cases the lower ribs are broken by strong contractions of the abdominal muscles, as in tetanus or child-birth.

Morbid anatomy.—The line of fracture is more transverse than oblique. There is no longitudinal displacement, as the antero-posterior diameter of the chest is maintained by the unbroken ribs. In cases of fracture by indirect violence, there may be some outward displacement of the fragments, or if the violence was direct, they may be driven inwards; but in either case the displacement is slight, owing to the natural elasticity of the chest wall.

When the fragments are driven inwards the intercostal vessels and nerves may be lacerated, or the pleura, lung, pericardium, heart, liver, diaphragm, or spleen injured, according to the situation of the fracture. Wound of the lung may occasion pneumo-thorax or surgical emphysema, and be followed by pneumonia; wounds of the heart are rare, and may be slight or serious; hæmo-thorax may ensue if the intercostal vessels and pleura are both wounded; while if the latter be intact, there will be considerable hæmorrhage beneath the skin.

Fracture may be bilateral and affect many bones, especially when it is due to severe compression of the chest in the antero-posterior diameter.

Signs.—Considerable pain of a sharp, pricking character is felt at the seat of fracture when pressure is made directly upon it, or indirectly through the sternum. Forced inspiratory movements cause sudden pain, the patient catching his breath; hence respiration is superficial, shallow, and embarrassed, especially if more than one rib is broken. In multiple and bilateral fractures the respiration may be abdominal only.

Crepitus can usually be easily detected, and the patient is quite conscious of the grating of the fragments; if this sign is not readily obtained, he should be directed to take a deep breath, while the surgeon uses the stethoscope over the suspected seat of fracture. If the lung has been wounded, hemoptysis and emphysema are valuable diagnostic signs. The diagnosis of fracture may be very difficult if the rib has given way near the angle.

Prognosis.—Union is complete in from three to four weeks. A good deal of callus is present owing to the impossibility of maintaining perfect rest, and this may bridge between and unite adjacent ribs. The prognosis depends upon the age of the patient, the number of ribs broken, and the presence or absence of concomitant injury and complications. If many ribs are broken, and especially if the lung is also wounded, the prognosis is very grave, and old people usually succumb.

Treatment.—The injured side must be strapped from below upwards with pieces of plaster about 3 inches long and reaching a little beyond the middle line in front and behind; these are best applied while the chest is in a position of expiration.

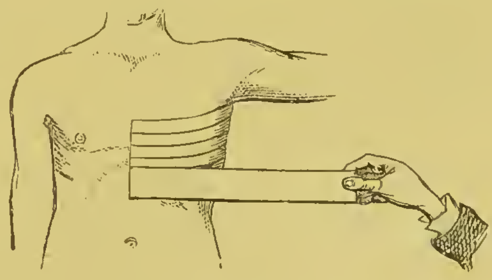


Fig. 121.—Method of strapping the chest (Berkeley Hill).

Each strip should overlap the preceding one by about two-thirds of its breadth. A body roller may be applied over the strapping, due care being taken that the chest is not too tightly confined. The arm on the injured side must be supported by a sling. If more than one rib is broken, the patient should be confined to bed in the dorsal position for a few days.

Complications must be treated according to their nature.

Surgical emphysema is sometimes very extensive, but subsides spontaneously in a few days.

FRACTURE OF THE COSTAL CARTILAGES

Fracture of the costal cartilages sometimes occurs, especially when they are ossified in advanced life. The signs and treatment are similar to those of fractured rib. Union takes place by bone.

FRACTURE OF THE STERNUM

The sternum may be broken by direct violence, or by forced flexion of the trunk; the accident is a rare one and dangerous in nature.

Direct violence applied to the sternum must be very great to cause fracture, since the bone is supported on the elastic ribs, through which the force is transmitted, and which are more likely to break near their angles, the sternum remaining intact. If there is displacement the upper fragment is posterior. The nature of the injury is usually apparent. There is pain, deformity, and crepitus, all exaggerated on deep inspiration; there may be more grave symptoms owing to concomitant injury of the pleura, lung, pericardium, or heart; or symptoms referable to these parts may supervene if secondary inflammation is excited by the injury.

Treatment consists of rest in bed in the dorsal position, the chest being encircled by strapping or a body roller. The patient should be kept in the recumbent position for three weeks.

DISLOCATIONS OF THE RIBS

The ribs may be displaced from the vertebræ, or from their cartilages, or the latter may be dislocated from the sternum. These accidents are rare, and are caused by direct violence acting on the chest.

Dislocation of the head of the rib is more common in the lower and more movable ribs, and is usually associated with fracture-dislocation of the spine from violent direct injury. The head of the rib slips forwards on the side of the vertebral body. The diagnosis is very difficult and often impossible. In suspected cases the patient should be treated as if the occurrence of the accident was certain.

Dislocation of the ribs from their cartilages, or of these from the sternum, are rare accidents. In most cases the rib or cartilage comes forwards, giving rise to a prominence beneath the skin, which may, when the patient takes a deep inspiration, readily disappear with a dull snap, only to return as the chest contracts.

Treatment.—If the head of a rib has been dislocated, the patient must be kept at rest, and the chest should be strapped as in cases of fracture.

If the ribs have slipped from their cartilages, or the latter from the sternum, reduction is easily accomplished by drawing the shoulders forcibly backwards, and at the same time directing the patient to take a deep breath. The maintenance of the proper position is, however, difficult, and may be impossible. The patient should be kept at rest for at least a fortnight. Permanent displacement is not a very serious matter.

WOUNDS OF THE CHEST WALL

These, when not penetrating, offer no special peculiarities. When very extensive, slight pleurisy occasionally results. If the question of penetration is doubtful, the wound should be carefully examined with the finger, but not by probing.

Penetrating wounds may, if made with a sharp instrument, appear externally as very trivial injuries; or, as in some gun-shot wounds, they may be large lacerated holes. The importance of any wound depends upon concomitant injury to the lung, heart, or great vessels, many such being immediately fatal. Penetrating wounds at the lower part of the chest may wound the diaphragm, spleen, liver, kidneys, or other abdominal viscera, especially if the instrument inflicting the injury has been thrust obliquely from above.

In all cases it is necessary to obtain a very accurate account of the nature of the accident and direction of the force.

Treatment.—Uncomplicated wounds should be carefully cleansed, sutured, and dressed antiseptically, the patient being kept at rest and secondary consequences watched for.

INJURIES OF THE PLEURA AND LUNG

The pleura may be wounded by penetration of the thorax, or by broken ribs, without any injury of the lung. As a rule slight local inflammation results, and healing is rapid, but if dirt has been

introduced into the sac, empyema may follow. Pneumo-thorax occasionally occurs, the air being drawn into the cavity during inspiration, and its escape during expiration prevented by the collapse of the chest wall and consequent closure of the orifice of the wound.

Contusion and rupture of the lung may result from simple concussion of the chest, from stabs or gun-shot injuries, or as a consequence of fracture of the ribs by direct violence. The damage done varies within wide limits, the effects varying with the nature of the violence and the seat of the laceration.

Signs.—There is more or less collapse, pain and difficulty in breathing, cough, and frothy, bloody expectoration. If the lung is merely contused, there may be localised dulness from extravasation of blood into the damaged area; the expectoration increases in amount for the first few days, during which time fine crepitation may be heard; but all the signs rapidly clear up and the patient recovers.

If the lung is ruptured, hæmoptysis may be copious, and, if the case is not at once fatal, hæmo-thorax, emphysema, pneumothorax, pneumonia, and perhaps empyema may result.

Treatment.—The patient must be kept perfectly quiet, and complications treated as they arise. If the hæmoptysis is great, it may be checked by the inhalation of turpentine, or by the injection of ergotine; the application of an ice-bag to the chest is probably useless, but opium, unless contra-indicated, is often exceedingly useful.

Wounds of the lung by stabs or gun-shot injuries are very serious, especially if the damage be inflicted near the root in the neighbourhood of the large vessels and bronchi.

Signs.—The signs of the injury depend very much upon the nature and extent of the damage, and the complications, *e.g.* pneumo- and hæmo-thorax, or emphysema, which may exist. There is more or less shock, and thoracic respiration is diminished; frothy, aërated blood may escape from the wound, or there may be profuse hæmoptysis with cough. Emphysema soon makes its appearance, and coarse râles, due to the blood in the tubes, are heard on auscultation. If the patient recovers from the immediate shock and hæmorrhage, pneumonia and empyema may seriously jeopardise his life.

Treatment.—All bleeding from the external wound must be arrested, and if this is small and clean cut it may be immediately sutured, but if large and ragged, it should be left open, and a drainage tube introduced just within the pleural cavity if there is

accumulation of blood in the sac. The wound must be dressed antiseptically, and the patient placed on the injured side to restrain its movements, ensure rest, and give the uninjured side full play. The pulmonary bleeding may be arrested by injections of ergotine and by inhalation of turpentine, and ice should be freely given by the mouth. When the injury is slight, healing is usually rapid. Wound of both lungs is almost invariably fatal.

Any complications which may arise must receive appropriate treatment.

Foreign bodies, such as bullets, may lodge in the pleural sac, and fall to the bottom posteriorly. A clean foreign body may become encysted by inflammatory effusion round it, and remain quite harmless, but in most cases empyema is excited. If a foreign body can be localised, it should be at once removed by an incision over it. Such bodies in the pericardium, heart, or lung are usually fatal.

COMPLICATIONS OF INJURY TO THE PLEURA AND LUNG

Hæmo-thorax may result from wound of the lung or pleura, or from damage of an intercostal artery, or of the internal mammary. If there is an external wound, blood wells up from it during inspiration, and is mixed with air, due either to concomitant injury of the lung, or to the entrance of air through the wound during inspiration ; in the latter case empyema rapidly ensues.

Signs.—There are the usual signs of profuse hæmorrhage, with rapidly increasing dulness extending upward from the base behind. The effused blood causes pressure on and collapse of the lung; hence there is dyspnœa, absence of the respiratory murmur, and of vocal fremitus. At the upper part of the lung, where it is uncompressed, there may be distinct tubular breathing.

Treatment.—The bleeding must be arrested by ligature of the vessel if possible, or by the use of ergotine, etc., if it proceeds from the lung. If the pressure on the latter is very great, the blood may be drawn off with the aspirator, or the clot turned out through an incision as for empyema. Removal of the blood should, however, be postponed for a few days if possible, since fresh bleeding may occur on withdrawal of the pressure unless the vessel be occluded by a firm coagulum.

If the hæmorrhage has been very severe, intra-venous injection of salt solution must be performed. Secondary inflammation and empyema must be watched for and receive the necessary treatment.

Pneumo-thorax may result from a wound of the lung, or from the entrance of air from without through a wound of the parietes. In the latter case the risk of infection and consequent empyema is much greater, since organisms may be introduced, whereas the air in the pulmonary alveoli is sterile, and hence cannot excite inflammation.

Signs.—There is great dyspnœa, or even orthopnœa. The chest is bulged, motionless, and is usually in the expiratory position; the lung is collapsed, and percussion gives a tympanitic or amphoric note. Metallic tinkling is heard, and if fluid is also present, the succussion splash is very evident.

Treatment.—A moderate amount of air in the pleural cavity is usually absorbed within a few days, and needs no special treatment. If the pressure exercised is great, the air may be withdrawn by a trocar.

Surgical emphysema may occur with or without injury of the lung or visceral pleura. If there is no wound of the lung, the air drawn into the wound in the parietes of the thorax during inspiration is, during expiration, forced into the cellular tissue of the deeper parts of the wound, the lips of which close during the expiratory collapse of the chest. If the lung is damaged, but the visceral pleura remains intact, the air passes beneath it towards the root, thence into the mediastinum, and to the root of the neck, and spreads along the upper limbs and trunk. If the visceral pleura is wounded, as in some cases of fractured rib, the air passes into the cellular planes of the chest wall in the neighbourhood of the injury.

Surgical emphysema may extend over the whole of the trunk, and even to the lower extremities, but is usually limited in area. The subcutaneous tissue is swollen, and, when pressed with the fingers, imparts a characteristic sense of dry crepitation; if air is present in considerable quantity, there may be a tympanitic note over the swelling, which is not altered in size by respiration.

Surgical emphysema is sometimes associated with pneumo-thorax.

Treatment is usually not needed, the air being readily absorbed in a few days. As the air from the pulmonary alveoli is sterile, there is no risk of inflammation. If the swelling is extensive gentle friction may be employed, or multiple small punctures be made.

Pulmonary collapse may result from pressure in pneumo- or hæmo-thorax, and from empyema. The treatment is directed to the cause.

Pleurisy and empyema.[1]—Simple adhesive pleuritis occurs as the result of injury, and leads to the formation of adhesions.

If dirt has entered the pleural sac from without, empyema will result, and the inflammation become diffused.

Pneumonia.[1]—Slight localised pneumonia may result from simple injury to the lung with or without wound of the chest wall. In such cases the inflammation is very limited in extent, produces few physical signs, and but little constitutional disturbance. It may, however, be very dangerous in the aged or enfeebled.

If infection has occurred as the result of external injury, rapidly spreading pulmonitis may ensue, often accompanied by empyema and proving fatal.

Prolapse and hernia of the lung.—When there is a large wound in the thoracic wall, the lung may be forced out of the cavity during expiration. The prolapse is usually small, but if large it is forced through the opening, and the base, being compressed, may become much congested or even gangrenous.

As a rule the opposed pleural surfaces become adherent, and no trouble results if the prolapse be reduced and its recurrence prevented by pressure. If the mass is large and gangrene is threatened, it may be removed by the knife or ligature.

If the chest wall has been weakened by injury or disease, the lung may protrude beneath the skin (hernia or pneumonocele). The tumour increases in size with inspiration, and is soft, crepitant, and resonant on percussion; there is no difficulty in diagnosis, the distinction between local abscess or perforating empyema being quite apparent. No treatment is necessary beyond protecting and supporting the swelling by strapping or some other means.

INJURIES OF THE PERICARDIUM AND HEART

The pericardium is occasionally torn as the result of severe contusion of the chest without any external wound; more usually both it and the heart are wounded by penetration of the thorax. In such cases the lung and pleura are nearly always involved. Injury of the pericardium without external wound is accompanied by considerable shock and rapidly followed by pericarditis with effusion, which enables a diagnosis to be made. At the time of the injury blood may be effused into the cavity, and will, if large in amount, more or less impede the action of the heart. Wound of the peri-

[1] For the physical signs, etc., of these conditions the reader is referred to works on Medicine.

cardium by penetration of the thorax may be diagnosed by the seat, direction, and mode of infliction of the injury, and by the escape of pericardial fluid, in addition to the indications already given; in such cases suppuration may ensue.

The heart may be ruptured—especially if its walls are thinned and weakened by disease—by concussion of the chest; but in most cases it is wounded, together with the pericardium and lung, by stabs or gun-shot injury. In rare cases fish-bones, etc., have passed from the œsophagus into the heart. The right ventricle, from its more exposed position, is the part most usually damaged, and then in order of frequency the left ventricle, right and left auricles.

The nature and extent of the wound varies with the method of infliction; thus it may only penetrate the wall or open the cavity, may be clean cut or lacerated, and may be so limited in extent that the patient recovers, or be (and usually is) immediately fatal. Wounds of the auricles are the most serious, since their walls are very thin, and hence penetration, profuse hæmorrhage, and instant death are almost certain.

A wound of the heart, if not immediately fatal, will probably be so within a short time; although it is stated that about 12 per cent of all cases recover. Hæmo-pericardium, pericarditis with effusion, or pyo-pericardium will ensue at once or within a few hours of the injury, and further add to the heart's embarrassment and the patient's danger.

When a man has been mortally wounded in the heart he may simply start up with a loud scream, throw up his arms, and fall dead; if the injury be not immediately fatal there is profuse bleeding, profound shock, coldness and pallor of the surface, and feeble and irregular action of the organ, soon culminating in death. Dyspnœa is also a marked symptom.

Treatment.—No active treatment can usually be undertaken beyond arresting the escape of blood by plugging the wound. Absolute rest must be observed, and stimulants should, as a rule, be withheld. If the blood in the pericardial sac is sufficient in quantity to embarrass the heart to a dangerous extent, it must be withdrawn, and the ensuing pericarditis or suppuration must receive the necessary treatment. Clean-cut wounds have been successfully sutured, and in fitting cases no hesitation should be felt in trying to save life by the operation.

It should be borne in mind that even should recovery ensue, the patient may develop an aneurismal dilatation at the seat of the cicatrix.

WOUNDS OF THE THORACIC VESSELS

Wounds of the vena cava, aorta, or large vessels of the thorax are immediately fatal from hæmorrhage.

The internal mammary or intercostals may be wounded by stabs, and the latter by fragments of broken ribs. These vessels should be secured at the seat of injury, the wound being enlarged, or a piece of rib excised if necessary.

CHAPTER XVII

Injuries of the Abdomen and Abdominal Viscera

CONTUSION OF THE ABDOMEN

Contusion of the abdomen is caused by severe violence, such as a kick or the passage of a cart-wheel, and may be associated with laceration of the parietal peritoneum or rupture of the muscles or viscera. Sudden death without any intra-abdominal lesion occasionally occurs, probably as the result of reflex inhibition of the heart through the solar plexus.

If there is much extravasation of blood, diffuse suppuration may extend between the muscular planes. When the parietal peritoneum is lacerated, there is considerable bleeding into the abdominal cavity, with severe shock, and symptoms closely simulating those of injury to the viscera. If the abdominal contents be damaged, the viscera, on account of their fixity and solid resisting nature, are more likely to be injured than are the intestines.

Symptoms.—The symptoms vary with the severity of the accident. In all severe contusions—especially if the injury is in the epigastric region near the solar plexus—whether there is internal injury or not, shock is very pronounced, and is due to sympathetic paralysis of the splanchnic area. Shock is especially deep and long continued—indeed, the patient may never rally—if internal injury has been sustained.

Faintness is constant, and actual syncope may occur; signs of internal hæmorrhage, with dulness in the flanks from accumulated blood, may be present. Vomiting is a prominent symptom, and pain is often severe. Great difficulty may be experienced in accurately diagnosing the true extent of the mischief; the surgeon should obtain, as far as possible, a complete account of the accident, and

should very carefully examine the abdomen with the view of testing the integrity of the organs. The urine must always be drawn off, the presence of blood being important evidence of injury of some part of the urinary tract. Persistent shock or signs of internal hæmorrhage are important indications of injury to a viscus.

Treatment.—If there be no reason to suspect internal injury, the treatment is mainly expectant. The patient should be rallied from shock, the thighs should be supported on a pillow to relax the abdominal wall, and warmth applied to relieve pain. Opium should be given every four hours in grain doses, provided its use is not contra-indicated, and the diet should be fluid and given in small quantities.

The signs and treatment of injury of the viscera will be presently considered.

RUPTURE OF THE ABDOMINAL MUSCLES

The abdominal muscles, especially the rectus, may be ruptured by severe direct violence or by strong contraction of the fibres as in tetanus or parturition. The accident is accompanied by considerable pain and swelling from extravasated blood, and a gap may be found in the continuity of the muscle. Any attempt at bringing the muscle into play aggravates the pain, and flexion of the trunk may be impossible. The abdominal respiratory movements are diminished or abolished. Diffuse suppuration may follow on the injury, or a ventral hernia may form at a later date as the cicatrix gradually yields.

Treatment.—The patient should be placed on his back, with the shoulders raised and the thighs flexed in order to relax the abdominal wall. The local application of ice arrests bleeding and promotes absorption of the effused blood. Rest may be maintained by a broad body-roller, and when the patient is well enough to get about, he should, if the injury is at all extensive, wear an abdominal belt.

Rupture of the diaphragm may occur from direct injury, which often involves neighbouring parts with fatal effects; or it may be due to violent contraction, as in vomiting, or to laceration by broken ribs; the injury in the last case is usually slight.

The rent is nearly always on the left side, close to the œsophageal opening, and if extensive the stomach or colon may protrude through it into the chest, or should the patient recover, a hernia may result from yielding of the cicatrix.

Signs.—There is great collapse with evidence of internal bleeding. Respiration is costal and shallow and the diaphragm moves but little. Thirst is a prominent symptom, and there is usually vomiting with great pain. If the stomach has passed into the thoracic cavity—as can be ascertained by percussion and physical examination—the lung may be compressed, the heart displaced, and its action hampered.

Treatment.—If the general condition of the patient warrants the operation, and the stomach or colon has escaped into the thorax, laparotomy may be performed, the hernia reduced, and an attempt made to close the rent by sutures. In other cases, absolute rest and rectal feeding for a few days is the only available treatment. Death is the rule.

The psoas magnus muscle may be ruptured by a violent strain and the accident may lead to the formation of abscess. The signs are equivocal. The patient complains of pain, especially on flexing the thigh or attempting to walk, and there is tenderness on pressure over the seat of rupture. Pain and stiffness on walking may persist for some time. Treatment consists in rest with the thigh flexed, and should an abscess form, it must be opened in the loin (see Spinal Caries, chap. ix. vol. iii.).

WOUNDS OF THE ABDOMINAL WALL

The importance of this class of injury depends upon the fact of penetration of the cavity and possible associated damage to the viscera. Non-penetrating wounds do not present any special features and require the same treatment as similar injuries elsewhere. If there is any doubt as to the *fact* of penetration, the wound, having been carefully cleansed, must be thoroughly examined and superficially enlarged if necessary. Penetrating wounds may be complicated by protrusion of the viscera, which may or may not be injured. If a viscus is wounded, the nature and extent of the damage varies with the method of its production. In nearly all cases of penetrating wound there is more or less shock, which is much deeper and more persistent if a viscus has been damaged.

Penetrating wound without protrusion.—The surgeon must satisfy himself—by enlarging the wound if necessary—that the intestines or viscera have escaped injury, and that no portions of clothing, etc., are lodged within the abdominal cavity. If any dirt has been introduced, the peritoneal cavity must be thoroughly cleansed by flushing with sterilised water or by sponging. When

all bleeding has been arrested, the wound is closed by sutures, as in the operation of laparotomy.

Penetrating wound with protrusion.—Protruded omentum, gut, etc., may or may not be wounded, or contaminated by dirt. The part should be at once cleaned with warm sterile water or weak boracic solution, and careful search should be made for any injury it may have sustained, which, if found, must receive the treatment indicated later on. It should be remembered that the parts within the abdomen may have been injured, although the protruded portion is intact. When the protruded part has been thoroughly cleansed and has received any suturing, etc., which may be necessary, it must be gently replaced. Reduction is often difficult and may require enlargement of the wound to accomplish it without undue force. If the omentum is bruised or fouled by dirt, it should be ligatured with chromic gut or silk and removed. When reduction has been effected, the peritoneal cavity must be cleansed and the wound closed with deep sutures. The after-treatment of penetrating wounds of the abdomen is that for laparotomy, coupled with that applicable to any viscus which may be injured.

INJURIES OF THE ABDOMINAL VISCERA

The contents of the abdomen may be damaged by severe contusion, or by a penetrating wound of the parietes. The liability to rupture of a viscus is naturally increased if it is enlarged or its consistency diminished by disease, or if the stomach and intestines be distended by solid or gaseous contents. Should the abdominal wall be lax and pendulous, the patient thin, or normal muscular resistance diminished by drunkenness or other cause, even slight contusion may produce a fatal internal injury, and this is more likely to be the case if the blow is directed full against the abdomen rather than at a tangent. The precise nature and seat of the internal injury necessarily varies with the nature and point of impact of the violence. The intestines are, from their free mobility and compressible nature, less likely to be damaged than are the more fixed and solid organs; of these the liver, spleen, and kidney are wounded in this order of frequency.

General symptoms and diagnosis.—**Shock** is very severe and persistent; the skin is clammy, the extremities cold, the heart's action depressed, the breathing shallow and thoracic, and there is great mental distress with an anxious and apprehensive expression of countenance.

Internal hæmorrhage may be very profuse and prove almost immediately fatal; short of this, the patient exhibits all the signs of great loss of blood which may accumulate in, and cause dulness of the flanks. The abdominal wall is tense and resistant, and the patient complains of severe continuous **pain**, which is aggravated by any attempt at movement and increases as shock passes off.

Thirst is a prominent symptom and **vomiting** is constantly present. If the vomited matter is bloody, injury of the stomach is indicated. If the stomach or intestine has been ruptured, there may be evidence of **free gas** in the abdominal cavity which may usually be inferred if the abdomen is tympanitic and the liver dulness is obliterated; the diagnosis may be made more clear by inflation of the stomach or gut with hydrogen, which can be easily generated at the bedside with zinc and sulphuric acid.

The **urine** should always be drawn off, and if blood is present the kidney will have sustained damage, provided rupture of the urethra or bladder be excluded, and no injury has been caused by the passage of the catheter. Should the patient survive the immediate effects of the injury, **acute peritonitis** quickly supervenes, and in most cases terminates fatally.

A certain diagnosis of the extent and nature of the internal lesion (in the absence of a penetrating wound which allows direct examination) is by no means always possible, for very similar symptoms are met with in severe contusion of the abdomen, especially if the parietal peritoneum has been lacerated and intra-abdominal bleeding has occurred.

The seat and nature of the injury, the presence and persistence of severe shock, and evidence of internal bleeding are the chief guides; but in any doubtful case laparotomy should be performed, the abdomen being opened in the situation indicated by pain and the impact of violence; or if there is a penetrating wound, this should be enlarged.

General treatment.—Every effort must be made to rally the patient from shock. Ergotine should be injected, and the ice-bag applied over the seat of injury with the hope of arresting bleeding. As soon as the condition of the patient permits, laparotomy must be performed and the wound treated according to its seat.

The surgeon should not perform any operation unless the symptoms are severe enough to warrant it; and, on the other hand, none should be performed in obviously hopeless cases. In the former case a useless operation considerably increases the patient's danger, and in the latter it brings deserved discredit on the

operator. When an operation has been performed and the damaged organ has received attention, and when all bleeding has been arrested, the blood-clot should be removed, the peritoneal cavity thoroughly cleansed, and the wound closed. If peritonitis is present, drainage should be employed.

Profuse hæmorrhage will necessitate the intra-venous injection of salt-solution, but this should only be done when the bleeding has ceased and the vessels have been secured.

The after-treatment of these cases consists in complete rest, with the use of opium for two or three days, the disuse of all food by the mouth, and the employment of nutrient enemata and suppositories.

If peritonitis sets in, the treatment indicated in that condition must be employed (chap. xviii. vol. iii.).

INJURIES OF THE STOMACH

The stomach is most likely to be ruptured by violence if it is distended, the rent in such cases being larger and the consequences more serious as the food and gastric juice escape into the peritoneal cavity. Traumatic rupture nearly always occurs near the pylorus, close to the greater curvature.

Signs.—There are the signs common to all intra-abdominal injuries (p. 333).

Vomiting is not necessarily present, but when it occurs, the vomited matter is bloody. There is extreme epigastric pain and tenderness, with great thirst. If air escapes into the abdominal cavity, the liver dulness may be diminished. In cases of doubt, the stomach may be inflated with hydrogen; if it is intact, the outline of the organ will be apparent, but if ruptured, the gas will fill the abdominal cavity.

Treatment.—The abdomen must be opened in the middle line above the umbilicus, or if a wound is present it should be enlarged. The rent is searched for, the cavity of the stomach washed out, and the wound closed with Czerny's suture. Every care must be taken to thoroughly cleanse the abdomen before closing the wound in the parietes, and drainage may be advisable.

All food by the mouth must be interdicted and the patient fed by nutrient enemata and suppositories for the first five or six days, at the end of which time fluid food in very small quantities may be given by the mouth.

INJURIES OF THE INTESTINE

The intestine may be crushed and torn by severe kicks or blows on the abdomen, or wounded by penetrating wounds or gun-shot injuries; in the latter case, the bullet may traverse many coils. The small intestine is more usually damaged than is the colon, the usual seat being the duodenum or upper part of the jejunum. These parts are specially liable to injury because the duodenum is fixed against the spine, and not being covered by peritoneum in its third part, is unable to slip aside or to withstand traction on the jejunum.

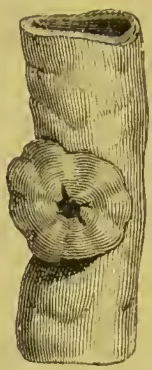


FIG. 122.—Bullet-wound of the jejunum showing the hernia of the mucous membrane (Follin).

If the intestine be severely contused without actual laceration of its coats the damaged tissue may slough, and perforation ensue, unless adhesions have occurred, when localised abscess will result.

If the intestine has protruded and been wounded outside the abdomen, the outlook is less serious, since the general cavity of the peritoneum may escape fæcal contamination, and hence the risk of septic peritonitis is diminished. When the wall is lacerated, the rent is transverse to the long axis of the gut and opposite the mesenteric attachment; complete division is very rare. The mucous membrane protrudes through the opening so that it looks smaller than it really is (Fig. 122), and if the wound be a mere puncture, the mucous membrane may completely close it so that extravasation of its contents is prevented.

Symptoms.—The symptoms common to all grave abdominal injuries are present (p. 333). Pain is constant and severe. Vomiting is persistent. Free gas in the peritoneal cavity may be present and give a general tympanitic note obliterating the liver dulness; occasionally gas passes beneath the peritoneum, causing emphysema of the abdominal wall.

Unless relieved the patient rapidly dies of acute septic peritonitis.

Treatment.—Wounds of the intestine must be treated by suture or resection according to the damage inflicted and the amount of contusion. If the edges of the wound are much damaged and irregular, they must be pared and then united. The abdomen must be scrupulously cleansed and the wound closed.

For the details of these operations see page 423, vol. iii.

INJURIES OF THE LIVER

The liver, on account of its size and position, is more frequently damaged by blows, kicks, stabs, or in cases of fracture of the lower ribs, than any other of the abdominal organs. A large fatty liver may be extensively damaged by very slight injury, and in such cases fat embolism may be extensive and fatal (p. 94).

The upper surface of the right lobe is the usual seat of the damage, which may be a simple contusion, a laceration without involvement of the fibrous or peritoneal investment, or may be so extensive as to completely pulp the part, and cause speedy death from hæmorrhage. Portions of liver substance are sometimes completely separated, or only remain connected to the organ by the stretched and frequently lacerated blood-vessels.

Contusion or rupture may lead to abscess, or repair may quickly ensue. In bad cases the patient either dies at once of hæmorrhage, or in a few days from peritonitis excited by the escape of bile and blood.

Signs.—The seat of the damage to the parietes, coupled with the evidence of internal mischief, is very suggestive of this injury. Owing to the accumulation of clot there may be an increase of the liver dulness. The respiratory movements are shallow and painful. If the patient survives the immediate injury, jaundice may supervene, and sugar in the urine is sometimes noticed.

Treatment.—If the symptoms are not urgent, and it is probable that the damage is slight, no operation need be undertaken, the usual treatment of abdominal contusion being sufficient. In more severe, but not hopeless cases, the abdomen should be opened over the probable seat of the damage. When this is exposed, sponge pressure will often arrest even smart bleeding, but should it fail after having been given a fair trial, the surgeon may plug the wound with gauze, or attempt to bring the edges together and so compress the bleeding vessels. The edges of the rent may be approximated by deep sutures of kangaroo tendon or silk.

INJURIES OF THE GALL BLADDER

This is a very rare and fatal accident. It is usually associated with rupture of thc liver, and the signs of the two conditions are practically identical. If the wound be clean cut, as in the case of a stab, it should be closed with Lembert's sutures; but if it be

extensive, completely piercing both the walls, or if the rent is much lacerated, cholecystectomy should be performed.

INJURIES OF THE SPLEEN

Injury of the spleen is rare on account of the protection afforded it by the ribs; it is a very dangerous accident, in consequence of the profuse hæmorrhage which occurs. The spleen is most likely to be ruptured when it is in a state of physiological or pathological enlargement, and in the latter case spontaneous rupture is not unknown.

Injury is mostly inflicted by the ends of the ninth, tenth, and eleventh ribs when fractured.

Negroes are especially susceptible to the effects of injury in the splenic region, sometimes even a slight blow proving fatal, although it has not occasioned any serious lesion of the organ.

Signs.—The seat of the injury to the body-wall, and the evidence of profuse internal bleeding, coupled with the signs common to all abdominal injuries, are the diagnostic features. Speedy death from hæmorrhage is common, the blood forming a large dull swelling in the left flank.

Treatment.—Removal of the organ is indicated if the bleeding cannot be arrested by pressure, or by deep sutures traversing the rent.

INJURIES OF THE KIDNEY OR URETER

Contusion and rupture of the kidney is usually caused by direct violence to the loin, occasionally by penetrating wounds or gun-shot injury.

Sometimes the ureter or pelvis of the kidney is injured, as by the passage of a cart-wheel over the lumbar region. The extent of the damage varies from mere contusion to pulping of the renal substance. As a rule the peritoneum remains intact, and hence the blood and urine collect behind it, or, if there is a wound, escape externally. Blood-clot may temporarily block the ureter, or if this has been wounded, the urine secreted by the kidney gradually escapes into the subserous connective tissue, and forms a large fluctuating swelling, which may gradually increase in size without causing any general or local disturbance except by its dimensions, or suppuration may follow.

Signs.—If the kidney has been extensively lacerated, profuse

hæmorrhage into the peri-renal tissue, or into the abdominal cavity if the peritoneum has been wounded, may prove immediately fatal. In less serious cases there is great pain, simulating renal colic, owing to the presence of clots in the pelvis and ureter. The urine is bloody, and there is a frequent desire to micturate. If the ureter has been torn, the urine is diminished in quantity; but little blood escapes into the bladder, and a fluctuating swelling forms in the loin. Nausea and vomiting are usually present.

If the patient survives the immediate injury, epithelial casts and albumen will probably be found in the urine in a few days, in consequence of reactionary inflammation. Suppurative pyelitis and nephritis, peri-renal abscess, or if the peritoneum has been damaged, peritonitis, are the secondary dangers.

Treatment.—In bad cases, where there is much hæmorrhage and the organ is presumably severely lacerated, it should be cut down upon by the lumbar incision, or if there be an external wound this should be enlarged. If the kidney be found hopelessly damaged, nephrectomy must be at once performed.

In less serious injuries every effort must be made to arrest further bleeding. The ice-bag must be continuously applied to the lumbar region, and injections of ergotine administered. Turpentine, in drachm doses with mucilage of acacia, is very useful to arrest the hæmorrhage; but it must be given with care, as it is liable to excite congestion and inflammation of the renal substance. Complete rest is, of course, necessary. Should signs of suppuration become manifest, the pus must be evacuated by a free incision in the loin.

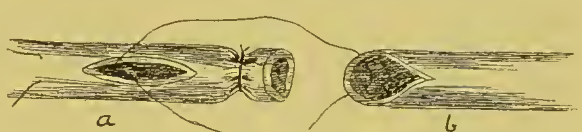


FIG. 123.—Diagram of the first stage of the operation for uniting a torn ureter. A thread is passed through the obliquely divided upper end (*b*). The lower end (*a*) is ligatured and incised a short distance from this point; through this incision the needles carrying the ends of the thread are passed, and are made to penetrate the coats from within out, about half an inch above the end of the incision; by traction on these threads the upper end is invaginated into the lower.

FIG. 124.—Diagram of the united ureter at the conclusion of the operation. The two ends, after the invagination is completed, are united by a few points of suture which should not pass through the entire thickness of the walls.

If urine collects round the kidney in cases of injury to its pelvis or ureter, the fluid may be withdrawn by aspiration, and should it re-accumulate, the operation may be repeated. If after one or two aspirations it

becomes evident that the ureter is torn across, or is impervious, nephrectomy must be performed, or in favourable cases the ureter may be cut down upon and united (Figs. 123, 124, p. 339).

FOREIGN BODIES IN THE STOMACH AND INTESTINES[1]

A foreign body, *i.e.* one which cannot be digested, may lodge in the stomach, in the lower part of the ileum, in the vermiform appendix, or just within the anus; but the great majority are voided with the fæces. Lodged in the stomach or intestine, a foreign body may remain for a long time without causing harm; but it may perforate the wall, especially if it be sharp and pointed, and set up local or diffuse peritonitis, according to whether there are adhesions or not. In some cases needles and similar objects may penetrate the stomach or intestinal wall, and appear at distant parts of the body, being moved along by muscular action, or else, being limited by adhesions, may become embedded in dense fibrous tissue, the resulting tumour closely resembling cartilage in appearance.

Undigested material, such as string, husks of grain, tea-leaves, etc., may form large ball-like masses, and remain for a long period in the stomach, or passing into the intestine, may produce symptoms of obstruction. When a foreign body has passed from the stomach into the intestine, it may be arrested at the ileo-cæcal valve, and cause chronic or acute obstruction.

FIG. 125.—A gall stone (reduced in size) which caused acute obstruction by impaction in the lower end of the ileum, necessitating enterotomy (Westminster Hospital Museum, No. 469. Drawn by C. H. Freeman).

Fig. 125 is a gall stone which I removed from the lower part of the ileum of a woman, æt. seventy, on account of acute obstruction. These gall stones enter the bowel through an artificial opening between the gall bladder and duodenum (chap. xviii. vol. iii.).

Symptoms.—So little disturbance is sometimes induced that a patient may be unaware that he has not passed the foreign body *per vias naturales.* Usually there is a feeling of uneasiness, pain, and weight in the epigastrium, coupled with indigestion and perhaps vomiting. If the body is arrested in the ileum, dyspepsia, flatulent distension, and symptoms of chronic or acute obstruction are induced.

[1] For foreign bodies in the rectum, see p. 351.

Treatment.—If it is known that a patient has swallowed a foreign body, such as a coin, which it may reasonably be hoped will pass, he should be fed for some days on thick gruel and similar matters, in the hope that it may be carried on in such semi-solid material. Purging should be avoided, but the fæces must be examined to ascertain if the treatment has been effectual.

Gastrotomy is only necessary if the foreign body is of such a nature that it cannot pass the pylorus. If a foreign body becomes impacted in the intestine, it must be removed through a linear incision, which should be closed by a double row of Lembert's sutures (chap. xix. vol. iii.).

Injuries of the Pelvis and Pelvic Viscera

FRACTURE OF THE PELVIS

Causes.—The pelvis is naturally protected against fracture by its shape, and the strength of the component bones, synchondroses, and ligaments. Fracture is caused by very severe direct violence, such as buffer accidents, crushes, and the impact of heavy objects falling upon it. Portions of the iliac crest may be broken off by kicks or blows, and the acetabulum may give way at its floor or margin by violent impact of the head of the femur, as in dislocation at the hip.

Morbid anatomy.—The injury may be of any degree of severity, from mere chipping of the crest or acetabulum to severe and fatal crushing with comminution. The line of fracture usually passes through the ramus of the pubes and ischium, and may extend posteriorly through the ileum close to the sacro-iliac synchondrosis, or the joint surfaces may be separated on the same or on the opposite side. More rarely the symphysis pubis is dislocated. When the pelvis is separated into two portions, these are connected by soft structures only, and the resulting damage is very severe.

Fractures of the iliac crest or margin of the acetabulum are comparatively trivial injuries; but if the floor of the latter be broken, there is usually considerable comminution, and the head of the femur may be forced upwards into the pelvic cavity, and inflict serious damage on its contents.

The severity and importance of fracture of the pelvis depends not so much on the fact of fracture as on the concomitant injury to the pelvic contents and the soft parts. Bruising is often very great, and there may be much extravasation from laceration of muscles, or

damage to important vessels. The bladder, urethra, or rectum may be torn by the fragments; such injury may prove immediately fatal, or excite severe inflammation and suppuration, which may either kill the patient, or materially retard the progress of healing and induce serious after effects.

Signs.—If the pelvis is broken right across, the patient is quite unable to stand, and feels as if falling to pieces. In less severe cases he may walk, but with pain and difficulty, and the diagnosis may be by no means easy. Pain is usually considerable, and is increased by movement of the trunk or lower limbs, by forced expiratory efforts, *e.g.* coughing, or by pressure on the iliac crests. There may be distinct irregularity in the outline of the pelvis, and examination by the rectum or vagina may reveal a fracture in the neighbourhood of the pubes or ischium. Mobility and crepitus can usually be detected. If the urethra has been wounded, blood may trickle from it; there will be a desire to micturate, but inability to perform the act, and the signs of extravasation soon appear on making the attempt. If the bladder is ruptured, pain and collapse are prominent symptoms.

Prognosis.—Bony union is usually complete in from six to eight weeks, but the patient may remain permanently lame from damage to the muscles, etc., and in any case will complain of weakness about the pelvis and lower limbs for many months. If the urethra has been damaged, traumatic stricture results.

Treatment.—A catheter should be passed, and if bloody urine is drawn off, it should be tied in; if the urine be clear, the bladder and urethra are intact and the instrument may be withdrawn. If extravasation of urine occurs, the treatment described on p. 347 must be adopted. In such cases the risk to the patient is considerably increased, since the wound in the perineum, made for the relief of the condition, will communicate with the seat of fracture, which is thereby rendered compound. Under such circumstances I have found the greatest benefit from free irrigation with boracic acid solution (4 grains ad ℥i) every two or three hours, the parts being thus kept perfectly clean and sweet.

The fracture itself must be treated by complete and prolonged rest. The patient should be placed in the dorsal position on a hard but comfortable mattress, with his knees tied together and a pillow beneath the thighs. A felt or gutta-percha splint must be fitted to the pelvis, extending down to the middle of the thighs like a pair of bathing drawers. This may be conveniently fixed in front by a strap and buckle, so that it can be readily removed if necessary. This plan will be found perfectly satisfactory and

preferable to plaster bandages, or any form of long splint to the trunk and thighs. Complete rest must be observed for at least two months, when the patient, still wearing the splint, may be allowed upon crutches; but he must not bear his whole weight on the pelvis for another month.

If the urethra has been lacerated, the resulting stricture must receive the necessary treatment.

Fracture of the rim or floor of the acetabulum must be treated as fracture of the femoral neck, the head of the bone being first reduced if it has been dislocated.

FRACTURE OF THE SACRUM AND COCCYX

Fracture of the sacrum is very rare; it is due to direct violence or gun-shot injury, and is always a severe accident. The injury is usually associated with crushing of the pelvis or wound of the viscera, and is frequently fatal.

The coccyx may be broken by kicks or other forms of direct violence, and occasionally by parturition in aged primiparæ. The fragment is displaced forwards by the coccygeus, and can be felt and reduced *per rectum*. There is usually considerable pain which may persist long after union has occurred (*coccydynia*), requiring for its relief subcutaneous isolation or removal of the bone.

Fractures of the sacrum and coccyx must be treated by complete rest, as in the case of fractured pelvis.

INJURIES OF THE URETHRA

FOREIGN BODIES IN THE URETHRA

Various foreign bodies may be introduced into the urethra, which, unless voided with the urine, tend to pass backwards into the bladder, where they may become encrusted with phosphates and form the nucleus of a calculus. Calculi may pass from the bladder into the urethra, usually lodging near the meatus, unless they are voided.

The effects produced by a foreign body depend upon its shape and size. Small ones may be passed with the urine, larger ones may remain impacted, causing partial or complete obstruction, and sometimes, by exciting ulceration and suppuration, escape into the peri-urethral structures. Sharp-pointed bodies may perforate the wall and set up perineal or scrotal abscess, unless speedily removed.

Difficulty in micturition and pain soon cause the patient to apply for relief, when the presence of the body is readily discovered by the catheter or endoscope. A negative history must not be relied on.

Treatment.—Some foreign bodies may be voided with the urine if the following manœuvre be adopted :—The patient, going on his hand and knees, compresses the urethra in front of the seat of impaction, and then forcibly contracts the bladder so as to completely distend the canal; still keeping up the contraction he releases his hold of the penis, when the sudden rush of urine at high pressure may wash away the foreign body, or bring it to the meatus, where it can be extracted with forceps. Should this method be unsuccessful, or unadvisable, owing to the shape and size of the body, an attempt may be made to remove it through the endoscopic tube, failing which, it must be cut down upon and removed through an external opening. Foreign bodies are rarely impacted in the female urethra, and can readily be removed after moderate rapid dilatation of the canal.

CONTUSION OF THE URETHRA

Contusion of the urethra by direct violence causes considerable swelling and bruising about the perineum and scrotum, and may occasion some hæmorrhage from the canal. There may be difficulty in micturition, owing to the effused blood compressing the urethra, but this soon passes off, and no ill effects result. Treatment consists in carefully passing a soft catheter and tying it in for a day or two if necessary, when pressure will be relieved by the absorption of the extravasated blood. The patient must be kept quiet, and an ice-bag should be applied to the perineum and morphia suppositories used if there be much pain.

LACERATION AND RUPTURE OF THE URETHRA

This injury may occur through direct violence applied to the perineum, and often results from the patient falling astride some resisting substance. Complete or partial rupture may be occasioned by the sharp fragments in fracture of the pelvis; more rarely, the urethra is torn during chordee, or from injury when the penis is erect. Obstruction of the canal by stricture or the lodgment of a foreign body may, during violent attempts at micturition, cause rupture of the urethra behind the seat of obstruction.

False passages are discussed in chap. xxvi. vol. iii. The mucous membrane is sometimes lacerated in attempts to remove foreign bodies, or on the withdrawal of a lithotrite with fragments of calculus in its jaws. These accidents are usually slight, and do not lead to the serious results attending rupture of the walls.

Morbid anatomy.—The rupture is usually limited to the floor of the urethra, but may be complete, especially when it is due to fracture of the pelvis. In the great majority of instances the laceration is in the membranous urethra, between the layers of the triangular ligament and below the resistant pubic arch; sometimes the prostatic portion is the seat of the damage. The prostatic portion and neck of the bladder may be affected in injury caused by fractured pelvis or penetrating wounds in the perineum. When the membranous urethra is torn, the anterior layer of the triangular ligament is usually ruptured, so that the urine readily passes beneath the fascia of Colles. The perineal structures are not usually wounded although they may be much bruised.

Signs and effects.—There is sudden and severe pain at the time of injury, escape of blood from the urethra, and urgent but often ineffectual attempts at micturition. Hæmorrhage is usually slight, unless a large vessel has been wounded, when it may be severe. The patient is perfectly able to contract his bladder, and may make strong attempts to void his urine, these only serving to increase the extravasation. If any urine passes along the urethra, it occasions some stinging pain as it comes in contact with the injured area. Retention may be complete either because the tube is torn across, or because the passage, partially torn, is compressed and occluded by extravasated blood.

There is bruising and ecchymosis in the perineum, perhaps extending to the scrotum.

Within a short time of the accident the signs of extravasation of urine are manifest, and with each contraction of the bladder, become more marked as fresh urine is poured into the tissues.

When the wound heals the cicatricial tissue gradually contracts, and traumatic stricture results.

Treatment.—If possible a No. 8 English catheter should be very carefully passed into the bladder and tied in for four or five days. If a soft instrument will not pass, a silver one should be tried, the roof of the urethra being carefully followed, but if the instrument cannot be made to reach the bladder—the beak passing through the rent into the cellular tissue—it should be passed as far as it will go without the employment of any force, and the end should

then be cut down upon in the middle line. The wound being enlarged, the surgeon should seek for the proximal end of the urethra, pass the catheter along it into the bladder, and then carefully suture the torn urethra with fine chromic catgut. The catheter should be retained for at least three days, provided it does not cause urethral fever. Free incisions must be made into the area of urinary infiltration, and means adopted to limit the ensuing inflammation and sloughing (p. 347).

The resulting stricture must be kept dilated by the passage of bougies.

EXTRAVASATION OF URINE

When there is a breach of continuity in the urethral wall, the urine is extravasated into the surrounding cellular tissue.

Traumatic rupture of the urethra leads to the most rapid extravasation. In stricture with retention, the urethra may yield during a violent effort at micturition, or perforation of the wall may be due to ulceration with the formation of perineal abscess. In the latter case the extravasation is gradual, and the urine, mixed with pus, is to some extent limited by an abscess sac. Perforation of the urethra by catheters is rarely followed by extravasation, partly because the wound is usually small, and partly because it runs in a direction opposite to that of the stream of urine.

Morbid anatomy and effects.—When the rent in the urethra is in the bulbous or membranous portions, the urine is extravasated beneath Colles' fascia, and passes forwards on to the scrotum and penis, and upwards on to the abdomen. The attachment of this fascia to Poupart's ligament, the rami of the pubes, and the base of the triangular ligament prevents the urine passing on to the thighs or backwards to the ischio-rectal fossæ, unless, as is very rarely the case, the attachment of the fascia has been torn by the injury. When the extravasation occurs from the membranous urethra, the urine reaches Colles' fascia by passing through the urethral opening of the triangular ligament, or in consequence of rupture of this structure, which frequently occurs in laceration of the urethra by violence. The parts into which extravasation has taken place are considerably swollen, such swelling increasing with time, and at each attempt to empty the bladder. The destructive effects of the extravasated urine depend in great measure upon its condition, the circumstances under which extravasation occurs, and the promptitude with which relief is afforded.

Healthy urine may cause but little harm if it be given free exit and further extravasation be prevented; but if the urine be putrid, as is so often the case in stricture, the consecutive inflammation, sloughing, and gangrene of the cellular tissue and skin may be very widespread and cause serious symptoms, or even death. Again, if extravasation is rapidly produced, the effects are more serious than if it occurs gradually in connection with perineal abscess, the walls of which tend to limit its area. If the nature of the case has been overlooked, and hence treatment not adopted, its gravity is naturally increased. When the inflammatory stage is reached, the scrotum, penis, and perhaps abdominal wall are much swollen and œdematous. The skin is smooth, shiny, tense, and livid, and gangrenous patches soon make their appearance. An incision into the scrotum releases a quantity of urine and purulent material which is often horribly offensive and enclosed in a cavity whose walls are gangrenous and shreddy.

During this stage the patient is very ill from septic absorption. The temperature is raised four or five degrees, the pulse fails, the tongue is dry and brown, and typhoidal symptoms quickly supervene and prove fatal unless relief be afforded. Sometimes the skin sloughs in various places and thus several openings are formed which, discharging pus and urine, remain as perineal fistulæ.

If the urethra be damaged behind the triangular ligament, as in cases of fracture of the pelvis, the evidences of extravasation are not so apparent, since the urine does not pass forwards beneath Colles' fascia, but infiltrates the cellular tissue of the pelvis; the subsequent danger from sloughing and septic absorption is greater than if the injury be more anterior.

Prognosis.—The danger to life depends upon the age of the patient and the state of the urine, bladder, and kidneys. Traumatic extravasation is rarely fatal, provided it be promptly treated. Extravasation consequent on stricture is much more serious on account of the usually unhealthy state of the urine, and the frequent presence of cystitis and renal mischief. Even the worst cases may recover if treated assiduously. Traumatic stricture always results.

Treatment.—If the extravasation is due to injury, the treatment described under rupture of the urethra must be adopted. In all cases free incisions must be made for the escape of the urine, so that inflammatory mischief may be reduced to a minimum. Hot fomentations should be constantly applied, and the parts should be irrigated with boracic solution. In a very severe case, due to stricture in a man aged sixty-five years, I succeeded in effecting

complete cure by continual irrigation for three weeks; if this be found impracticable, the patient should be kept in a hot boracic bath until healthy granulation is established.

In cases of stricture the natural passage must be re-established, or a permanent fistula will result. If the urine is unhealthy, every endeavour must be made to improve the state of the bladder (see Cystitis, vol. iii.).

The patient should have a liberal allowance of nutritious and easily digested food, and, as soon as the temperature falls to normal, the diet must be generous.

Stimulants are usually needed, and are to be given in quantities regulated by the pulse and tongue. Subsequent contraction of the urethral passage must be prevented by the use of bougies.

INJURIES OF THE BLADDER

FOREIGN BODIES IN THE BLADDER

Foreign bodies passed into the urethra, especially in the female, may enter the bladder, or portions of catheters, etc., may break off within it.

The signs of a foreign body are similar to those of calculus and it can be detected by the sound. It soon excites cystitis, and becoming incrusted with phosphates, may form the nucleus of a stone.

If possible, a foreign body should be removed with a lithotrite; but if its shape, size, or incrustation with phosphates render this impossible, median or supra-pubic cystotomy must be performed.

RUPTURE OF THE BLADDER

Causes.—Rupture of the healthy bladder may occur in fracture of the pelvis, and in penetrating wounds of the abdomen, perineum, or vagina; more usually it is caused by a violent blow in the hypogastric region when the viscus is distended and the patient intoxicated, in which condition the abdominal muscles are relaxed and do not afford the usual protection.

Falls and indirect violence occasionally cause rupture if the bladder is fully distended.

A bladder which is atrophied and sacculated may rupture from very slight causes, even from simple overdistension. Simple distension without violence never causes rupture of a healthy bladder, since the weaker membranous urethra yields before the stronger

bladder-wall; moreover, when the tension of the urine in the bladder is sufficiently high, the kidneys cease secreting.

Rupture of the bladder in women is rare, but it has occasionally occurred during parturition; more usually the pressure of the child's head causes bruising, which may terminate in sloughing and the formation of a vesico-vaginal fistula.

Morbid anatomy.—The position and nature of the rupture depend chiefly upon the method of its production. Injury applied through the hypogastrium and indirect violence cause the bladder to rupture posteriorly where it is covered by peritoneum; the rent is usually linear and runs vertically or slightly obliquely from the urachus towards one of the ureters.

If the injury be caused by fracture of the pelvis, or by a penetrating wound through the perineum, it affects the lower segment of the bladder where it is uncovered by peritoneum. As a consequence of rupture, blood and urine escape into the peritoneal cavity or pelvic cellular tissue, according as the rent is intra- or extra-peritoneal, and speedily excite inflammation, especially if the urine be unhealthy from old cystitis.

Signs—Intra-peritoneal rupture.—If the bladder be much distended at the time of injury, the patient will experience temporary relief as the urine escapes, but this is quickly followed by intense burning pain and collapse. There is intense desire to micturate, but the attempts are either ineffectual, or at most a little bloody urine escapes from the urethra. Unless there be a tight stricture, a catheter can be readily passed into the bladder, but no urine save perhaps a few blood-stained drops is withdrawn; the instrument, which should be of metal, is felt to be firmly grasped by the bladder, any attempt at curving the beak downwards causing an aggravation of the pain. A little manœuvring will usually enable the instrument to pass through the rent into the abdominal cavity, when blood-stained urine is drawn off in considerable quantity, and by depressing the catheter its point may be made to impinge against the abdominal wall—a procedure not, however, to be recommended.

As the urine escapes the stream is not continuous, but varies with respiration.

Should there be any doubt about the fact of rupture, warm boracic acid solution may be injected, and if the bladder is intact, it will be found to rise above the pubes, and the same quantity of fluid which is injected can be drawn off again; neither of these results will happen in cases of rupture.

As the patient lies in bed the urine may gravitate to the loins, giving rise to dulness, the extent of which varies with position.

Extra-peritoneal rupture.—If the rent be extra-peritoneal the bladder may still hold some urine, which, mixed with blood, may be passed *per urethram*.

The urine in these cases infiltrates the pelvic cellular tissue, and extends upwards between the abdominal wall and peritoneum, causing dulness in the hypogastrium, and, therefore, if the catheter passes through the rent, no such great flow of urine is obtained as in the intra-peritoneal injury.

Within a few hours of the accident the signs of acute peritonitis or pelvic inflammation make their appearance and speedily prove fatal. Rupture of the bladder is one of the most serious accidents, and is too frequently fatal, the gravity increasing with every hour that the patient remains untreated.

Treatment.—**Intra-peritoneal** rupture of the bladder must be treated by immediate suture. The bowel should be emptied by enema, the patient etherised, and an incision made in the middle line extending to the pubes. The wound should be carefully deepened in order that the surgeon may ascertain if there is urine between the abdominal wall and peritoneum, indicating extra-peritoneal injury, in which case the serous membrane should not be opened. When the abdominal cavity is opened, the intestines are held aside and protected by a large warm sponge, the buttocks are well raised, and the bladder brought up into the wound, all urine and blood-clot having first been removed from the pelvic cavity. If there is any difficulty in drawing the bladder well up, a thread may be passed through its muscular coat and drawn forwards by an assistant, or the rectal bag may be used. The seat of injury being now fully exposed, the rent is cleansed and the edges approximated by silk sutures passing through the peritoneum and muscular coat, but not including the mucous membrane. The sutures should be about one-eighth of an inch apart, and should extend one-quarter of an inch beyond each angle of the rent. Care must be taken that the serous membrane is brought into apposition. When the sutures have been tied, the bladder is filled with boracic solution to test their efficacy, and if any leak be found, additional sutures must be introduced. Finally, the abdominal cavity is thoroughly cleansed, and the wound closed. If there is any peritonitis, it will be wise to introduce a glass drainage tube for a few days. A Jacques catheter must be passed just within the neck of the bladder and retained for a few days to ensure due escape of

the urine, or drainage may be provided through a perineal opening.

Extra-peritoneal rupture is treated on the same plan as extravasation of urine. The bladder is drained by catheter or perineal incision, and the extravasated urine given exit through properly placed incisions.

INJURIES OF THE SCROTUM, TESTICLE, AND CORD

Wounds of these parts are not common, on account of their mobility and the laxity of the scrotal tissues. Laceration of the scrotum may expose the testicles, which, however, slip aside and are rarely injured. A blow may cause rupture of a varicocele and rapid effusion of blood into the tissues (Scrotal Hæmatocele, chap. xxvii. vol. iii.). Contusion of the testicle is not uncommon, and causes intense sickening pain, passing along the cord to the loins. There may be vomiting, and nausea is constant. A crush of the testicle is a serious accident; it produces faintness and collapse, and has been known to cause sudden death from reflex inhibition of the heart. Injuries of the testicle may be followed by acute orchitis, hydrocele, hæmatocele, or sarcoma. The vas deferens is occasionally divided or wounded in the operation for hernia or varicocele.

The treatment of these injuries is conducted on ordinary principles. Scrotal wounds should be carefully cleaned and united by horse-hair sutures. Contusions of the testicle require a few days' rest, the application of the ice-bag, and the use of a suspender for some weeks. If the organ is crushed or lacerated, it should be removed. Accidental division of the vas does not necessarily call for castration; in one such case I successfully employed fine silk sutures, the testicle did not apparently suffer, and some months afterwards was of normal size and consistence.

INJURIES OF THE RECTUM

FOREIGN BODIES IN THE RECTUM

Foreign bodies of the most varied description are occasionally introduced into the rectum, especially by women and those of weak intellect. If small, the body may slip up out of reach, but is usually easily voided during defæcation. Large bodies may not only wound the mucous membrane when introduced, but may occasion inflammation and ulceration, and occlude the passage.

Intestinal concretions, fish-bones, etc., may come from the alimentary canal and lodge just within the sphincter; if sharp and pointed, they may penetrate the wall of the bowel and excite suppuration, and the formation of fistula.

Treatment.—The removal of large foreign bodies is often very difficult and dangerous. The anus should be fully dilated, and the body grasped with forceps and carefully withdrawn. If necessary, an incision may be carried back to the coccyx, and the foreign body broken up before removal.

WOUNDS OF THE RECTUM

The rectal wall may be wounded by penetrating wounds of the perineum or during parturition. More rarely, injury has been caused by fracture of the sacrum, the forcible introduction of foreign bodies, the use of the long enema tube or of the rectal lever for compressing the iliacs.

Quite superficial wounds of the mucous membrane are not serious, provided strict cleanliness be observed. Narrow penetrating wounds, those made from within and those involving the peritoneal cavity, are especially liable to be followed by septic cellulitis or peritonitis. The escape of gas and fæces through an external wound is diagnostic of involvement of the bowel. If a sharp instrument, such as a stake, has entered the perineum or the anal orifice, the latter should be fully dilated, and the rectum thoroughly explored through a full-sized speculum. If it seems probable that the upper part of the bowel has been perforated, hydrogen gas may be introduced; should the wound extend to the peritoneal cavity, the abdomen will become distended and tympanitic.

Treatment.—Superficial wounds of the mucous membrane must be kept clean by irrigation and the use of iodoform, and the bowels should be confined for a few days.

Penetrating wounds through the perineum, and those made from within, are best treated by dividing all the tissues into the rectum, the case being treated as one of fistula.

If the peritoneal pouch has been wounded, or if the gut has been perforated high up, abdominal section is the safest procedure, since it enables the surgeon to clean the peritoneum and suture the rent.

In all cases, bleeding must be carefully arrested, any foreign body removed, and frequent irrigation resorted to in order to prevent septic inflammation.

RUPTURE OF THE PERINEUM

This accident is nearly always due to parturition, but may be occasioned by direct violence. The extent of the rupture varies; there may be a slight lateral or mesial rent, or the rupture may extend through the posterior vaginal wall into the rectum. If union is not obtained in extensive cases, prolapse of the vagina and rectum ensues.

Treatment.—If the rent is quite small, nothing is needed but the observance of rest and strict cleanliness, and the use of the antiseptic douche.

If any sutures are needed, they should be introduced at once, while the parts are anæsthetic in consequence of prolonged pressure. The best materials are silkworm-gut and horse-hair. If the rectum is involved, three or four sutures should unite its walls and be brought out through the anus, while others unite the vaginal wall, and some pass deeply across the torn perineum. The knees should be tied together, and the patient placed, if possible, in the prone position, so that the discharges and urine do not pass over the wound or soak into it. The bowels should be confined for a week or ten days, and the sutures left for two or three weeks, during which time the patient is kept in bed and the parts kept clean by free douching and iodoform.

Old-standing ruptures must be treated by a plastic operation, for accounts of which the reader is referred to a standard work on Gynæcology.

INJURIES OF THE VULVA

Wound of the vulva may occur during parturition or from direct violence. Bleeding is usually very profuse, but is easily arrested by the application of hot water, the larger vessels being ligatured. These wounds must be treated on ordinary principles, and heal readily owing to the vascularity of the parts.

Hæmatoma of the vulva, resulting from severe bruising or rupture of a varicose vein, gives rise to a soft fluctuating swelling, with ecchymosis of the superficial tissues. A tumour forms suddenly; it is livid and tense, but under the application of cold the blood is usually soon absorbed, and the swelling becomes smaller and harder. Suppuration sometimes occurs.

FOREIGN BODIES IN THE VAGINA

Children, lunatics, and women of perverted moral sense occasionally introduce foreign bodies of the most diverse character into the vagina. Pessaries which have been wrongly introduced without the patient's knowledge may remain in the vagina for long periods, and occasionally pieces of sponge and similar objects, introduced with a view to preventing impregnation, have to be removed by the surgeon. The introduction of a foreign body may inflict serious damage on the parts, and ultimately excite severe inflammation and ulceration with profuse fœtid discharge, finally compelling the patient to seek that medical assistance to which feelings of shame prevented her earlier resorting.

Examination with the speculum will reveal the position of the foreign body, which can then be removed by forceps. In some cases an anæsthetic is necessary, and great care must be observed in removal, otherwise serious damage may be inflicted on the vaginal walls.

LACERATION OF THE VAGINA

Laceration of the vagina may occur during delivery, but may also be caused by accident, attempts at procuring abortion, violent intercourse, or rape. The extent of the damage varies within wide limits; the mucous membrane may be torn or the wound may extend into the peritoneal pouch, rectum, or bladder, according to the method of its production.

Punctured wounds in the upper part (usually posteriorly) usually result from attempts at the production of abortion, and may pass into the pelvic cavity. Extensive wounds may be at once fatal from shock or hæmorrhage. Secondary inflammation and septic absorption are—especially if the wound occurs in association with parturition or abortion—to be particularly feared.

Severe bruising of the vagina without any actual breach of surface may result from protracted labour, and may be followed by sloughing of the parts and the formation of fistulæ with the bladder or rectum.

Treatment.—The extent of the wound must be accurately ascertained, and all bleeding arrested by ligature, hot water, or plugging, according to circumstances. The parts must be thoroughly cleaned and kept aseptic by constant douching with boracic solution. If the peritoneum has been wounded, the parts should be plugged with antiseptic gauze.

RUPTURE OF THE UTERUS[1]

The gravid uterus may be wounded by stabs or blows on the abdomen, and the lower segment may be penetrated by sharp instruments in attempted abortion. Rupture is nearly always due to difficult parturition, rough and unskilful instrumentalism or turning, and is predisposed to by malposition of the fœtus, contracted pelvis, or any pathological condition impairing the strength of the uterine walls. Rupture of the uterus seems to be more common in multiparæ, although in primiparæ slight tears of the cervix are not infrequent; these are nearly always bilateral. During parturition, the cervical segment of the uterus, which is bounded above by a ridge of contracted muscular tissue (Bandl's ring), is thinned and stretched. It is this thinned segment which is the seat of rupture. The rent may only extend through part of the thickness of the wall, or may implicate the peritoneum or vaginal vault. Lacerations of the cervix are important from the fact that they open up paths for the absorption of septic material, and, if severe, entail later consequences which may necessitate operative interference.

Signs.—Rupture usually occurs during a strong uterine contraction. The patient experiences temporary relief from pain, but speedily exhibits symptoms characteristic of shock and hæmorrhage. Blood may pour copiously from the vagina, or it may be extravasated into the peritoneal cavity. Vaginal examination will reveal the rent, and the intestines may be felt protruding. The presenting part will recede, and abdominal palpation may show that the child has escaped partially or wholly into the abdominal cavity.

Treatment.—If the child is still within the cavity of the uterus, delivery must be accomplished as soon as possible *per vias naturales.* The rent must then be plugged with iodoform gauze, and thorough cleanliness maintained by free douching. If the child has escaped into the peritoneal cavity, laparotomy is imperative, and may also be performed and the rent sutured in all cases if the patient's condition warrants the operation. Intra-venous injection of saline solution must be resorted to if hæmorrhage has been excessive. In some cases rupture of the uterus is best treated by Porro's operation.

[1] For a full account of the subject, the reader is referred to works on Obstetrics and Gynæcology.

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